DOCUMENT RESUME

ED 285 518 IR 012 723

AUTHOR Simonson, Michael R., Ed.; Zvacek, Susan M., Ed.
TITLE Proceedings of Selected Research Paper Presentations at the Annual Convention of the Association for Educational Communications and Technology and Sponsored by the Research and Theory Division (Atlanta, Georgia, February 25-March 1, 1987).
INSTITUTION Association for Educational Communications and Technology, Washington, D.C.
PUB DATE Feb 87
NOTE 777p.; For individual papers, see IR 012 724-774 and ED 283 505.
PUB TYPE Collected Works - Conference Proceedings (021) -- Reports - Descriptive (141)

EDRS PRICE MF05/PC32 Plus Postage.
DESCRIPTORS Aptitude Treatment Interaction; Cognitive Processes; Cognitive Style; *Computer Assisted Instruction; Distance Education; *Educational Media; *Educational Technology; Educational Television; *Instructional Design; Instructional Development; *Instructional Effectiveness; Interactive Video; *Media Research; Problem Solving
IDENTIFIERS AECT Research and Theory Division Meeting

ABSTRACT

Current issues in educational communications and technology are addressed in this collection of 51 papers, which are mainly research reports. The first five papers were prepared for a symposium on the status of research in instructional technology, an introduction and four discussions of divergent points of view in the current controversy over the instructional effectiveness of media. Other topics addressed by the remaining papers include research methodology, software evaluation, intelligent computer-based education systems, effects of media on learning in science and reading, interactive videodisks, instructional television, aptitude treatment interaction, instructional design and development, schema theory, locus of control, cueing and other orienting activities, problem solving, distance education, and teacher attitudes and computer equity. The names and addresses of the Association for Educational Communications and Technology Research and Theory Division officers, directors, and review board are provided, as well as cumulative author and descriptor indexes for the 1985, 1986, and 1987 editions of the proceedings. (MES)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED285518

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)
☒ This document has been reproduced as received from the person or organization originating it.
☐ Minor changes have been made to improve reproduction quality
- Points of view or opinions stated in this document do not necessarily represent official OERI position or policy

PROCEEDINGS OF SELECTED RESEARCH PAPER PRESENTATIONS

at the 1987 Convention of the
Association for Educational Communications and Technology
and sponsored by the
Research and Theory Division
in
Atlanta, GA

Edited by:

Michael R. Simonson
Professor of Secondary Education

and

Susan M. Zvacek
Teaching Assistant

Iowa State University
College of Education
Instructional Resources Center
Lagomarcino Hall
Ames, Iowa 5011
(515) 294-6840

IR012723

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY
Michael R.Simonson

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

BEST COPY AVAILABLE

PREFACE

For the ninth year, the Research and Theory Division of the Association for Educational Communications and Technology (AECT) is publishing these Proceedings. Papers published in this volume were presented at the national AECT Convention in Atlanta, GA. A limited quantity of this volume were printed and sold. It is also available on microfiche through the Educational Resources Information Clearinghouse (ERIC) system.

REFEREEING PROCESS: All Research and Theory Division research papers selected for presentation at the AECT Convention and included in this Proceedings were subjected to a rigorous blind reviewing process. Proposals were submitted to Dr. Randall Koetting of Oklahoma State University, who coordinated the review process. All references to author were removed from proposals before they were submitted to referees for review. Approximately sixty percent of the manuscripts submitted for consideration were selected for presentation at the Convention and for publication in these Proceedings. The papers contained in this document represent some of the most current thinking in educational communications and technology.

This volume contains two cumulative indexes covering the most recent three volumes, 1985-1987. The first is an author index. The second is a descriptor index. The two indexes will be updated in future editions of this Proceedings. The index for volumes 1-6 (1979-84) are included in the 1986 Proceedings.

M. R. Simonson
Editor

ERIC DOCUMENT NUMBERS for PREVIOUS EDITIONS of the PROCEEDINGS

Year	Location	ED Number
1979	New Orleans	171329
1980	Denver	194061
1981	Philadelphia	207487
1982	Dallas	223191 to 223236
1983	New Orleans	231337
1984	Dallas	243411
1985	Anaheim	256301
1986	Las Vegas	267753

TABLE OF CONTENTS

"...MERE VEHICLES..." A SYMPOSIUM ON THE STATUS OF RESEARCH IN INSTRUCTIONAL TECHNOLOGY 1
"...Mere Vehicles..." Symposium Introduction
By Michael R. Simonson
Which Technology for What Purpose?: The State of the Argument About Research on Learning from Media
By Richard E. Clark
Computer-Based Instruction: What 200 Evaluations Say
By James E. Kulik and Chen-Lin C. Kulik
Computer-Based Enhancements for the Improvement of Learning
By Robert D. Tennyson
Are Media Merely Vehicles for Instruction?
By William Winn

Prose-Relevant Pictures and Recall From Science Text
By Gary J. Anglin and J. Truman Stevens 49

Introverted Approaches to Instructional Media Research: Eliciting Perceptual Processes Which Contribute to Learning
By Ronald J. Aust 63

Reader Theories and Educational Media Analysis
By Ann DeVaney Becker 83

Evaluations of Educational Microcomputer Courseware/Software: A Content Analysis of Published Reviews
By Evelyn Bender 99

MAIS: An Empirically-Based Intelligent CBI System
By Dean L. Christensen and Robert D. Tennyson 119

Effects of Using On-Screen Learning Aids and Reading Performance
By Chu, Hsiang-Chi, Julie 133

Research on Learning from Interactive Videodiscs: A Review of the Literature and Suggestions for Future Research Activities
By Marcia B. Cushall, Francis A. Harvey and Andrew J. Brovey 152

Some Advantages and Disadvantages of Narrow-Cast Instructional Television: One Instructor's Experience
By David W. Dalton 161

Aptitude-Treatment Interaction Research Revisited
By Marcy P. Driscoll 171

The Effect of Varied Practice Activities in Complementing Visualized Instruction
By Carol A. Dwyer 183

Fiction as Proof: Critical Analysis of the Form, Style, and Ideology of Educational Dramatization Films
By Elizabeth Ellsworth 205

An Historical Analysis of Form, Style, and Instructional Design in Teaching Films
By Barbara Erdman 221

The Idea of the Schema
By Robert M. Gagne 229

Effects of Television and Picture Book Attributes on Children's Memory of Visual and Auditory Facts
By Elinor C. Greene, Rengen Li and Brenda C. Litchfield 235

How Does the Match Between Media and Learners' Preferred Perceptual Modes Affect Literacy Learning?
By Suzanne M. Griffin 247

Psychotechnology as Instructional Technology: Systems for a Deliberate Change in Consciousness
By David G. Gueulette and Connie Hanson 259

The Role of Practice Versus Cueing During Computer-Based Instruction
By Michael J. Hannafin 277

The Effects of Locus of Instructional Control and Practice on Learning From Interactive Video
By Michael J. Hannafin and Maryanne E. Colamaio 297

Queueing Theory: An Alternative Approach to Educational Research
By Sarah H. Huyvaert 313

Implications of An Attention Reduction Training (ART) Model for Education and Technology
By John W. Jacobs, John V. Dempsey
and David F. Salisbury 337

Field-Dependence/Independence and the Mathemagenic Effects of Observable Visual Imagery Rehearsal for Learning Computer-Presented Text
By John H. Joseph 361

Finding One's Way in Electronic Space:
The Relative Importance of Navigational Cues and Mental Models
By Stephen T. Kerr 373

A Comparison of a Microcomputer Progressive State Drill and Flashcards for Learning Paired Associates
By James D. Klein and David F. Salisbury 401

Teachers' Opinions and Attitudes About Instructional Computing: Implications for Student Equity
By Nancy N. Knupfer 419

Schema Activation and Pre-Instructional Strategies
By Rengen Li 459

The Effect of Stories and Diagrams on Solution of an Analogous Problem
By Carla Mathison and Brockenbrough S. Allen 471

Comprehension and Recall of Television's Computerized Image: An Exploratory Study
By Nikos Metallinos and Sylvie Chartrand 481

An Agenda for Research on Instructional Development
By Michael Molenda 513

Microcomputer Interactive vs. Traditional Associative Learning in a Paired-Associative Recall Task
By Barbara S. Newhouse 535

An Alternative Belief: Negative Aspects of Educational Technology
By Randall G. Nichols 553

Prospectus for New Directions in Educational Film Research
By Daniel J. Perkins 575

The Effects of Practice and Orienting Activities on Learning From Interactive Video
By Timothy L. Phillips, Michael J. Hannafin and Steven D. Tripp 585

The Effects of Textual and Animated Orienting Activities and Practice on Application and Problem Solving Skills in an Elementary Science Lesson: An Exploratory Study
By Lloyd P. Rieber and Michael J. Hannafin 599

Schema Theory and Signaling: Implications for Text Design
By Stephen Rodriguez 613

Effects of Media on Children's Inference Justifications
By Stephen R. Rodriguez, Deborah S. King, and Naja G. Williamson 625

Computer-Based Instruction Research: Implications for Design
By Steven M. Ross, Gary R. Morrison, Pandma Anand, and Jacqueline K. O'Dell 639

Research in Distance Education: A System Modeling Approach
By Farhad Saba and David Twitchell 661

The Effect of the Number and Nature of Features and of General Ability on the Simultaneous and Successive Processing of Maps
By Sandra Sutherland and William Winn 681

Schema Theory: A Basis for Domain Integration Design
By Katsuaki Suzuki 697

The Effects of Program Embedded Learning Strategies, Using an Imagery Cue Strategy and an Attention Directing Strategy, to Improve Learning from Micro Computer Based Instruction (MCBI)
By William Taylor, James Canelos, John Belland, Frank Dwyer, and Patti Baker 709

Field Dependence-Independence and Learning from Instructional Text
By Merton E. Thompson and Marcia E. Thompson 733

Application of Schema Theory to the Instruction of Arithmetic Word Problem Solving Skills
By Chia-jer Tsai and Sharon J. Derry 745

The Use of Computers in Text Research: Some Reflections on a Seminar
By Walter Wager 757

Computers and Instructional Design: Component Display Theory in Transition
By Brent G. Wilson 767

Real-Time Graphics for CAI: A Rudimentary Grammar and Demonstration Program
By Bill Winn 783

Electronic Text Display: An Experiment on Page Turning and Window Effect
By Andrew R. J. Yeaman 805

Research & Theory Division Officers

Tillman Ragan (President, 1985-86)
Collings Hall work: (405) 325-1521
The University of Oklahoma home: (405) 364-5970
Norman, OK 73019

David Jonassen (President-elect, 1985-86)
1250 14th St., 2nd floor work: (303) 556-2717
Univ. of Colorado at Denver
Denver, CO 80202

Louis Berry (Past president, 1985-86)
103 LIS Building work: (412) 624-6910
University of Pittsburgh
Pittsburgh, PA 15260

Jim Canelos (Newsletter Editor)
Engineering Dean's Office work: (814) 863-2926
101 Hammond Building
University Park, PA 16802

Board of Directors

Melvin Bowie (1984-87)
University of Arkansas
Fayetteville, AR 72701
(501) 575-5444

Frank Clark (1984-87)
College of Educ. & Grad. College
Texas A & M University
College Station, TX 77840
(409) 845-3631

Marina Stock McIsaac (1983-86)
Department of Educ. Techn. Box FLS
Arizona State University
Tempe, AZ 85281 (602) 965-7191

Steven Kerr (1985-88)
412 Miller Hall DQ-12
University of Washington
Seattle WA 98195 (206) 543-1877

Patricia Smith (1986-89)
Dept. of C & I
University of Texas Austin
Austin, TX 78712 (512) 471-5211

Michael Streibel (1983-86)
528-F Teacher Education Building
University of Wisconsin
Madison, WI 53706 (608) 263-4674

Phil Brody (1983-86)
Baily Hall Annex
University of Kansas
Lawrence, KS 66045 (913) 864-3057

Catherine Fosnot (1986-89)
148 Davis Hall
Southern Conn. St. Univ.
New Haven, CT 06515
(203) 397-4662

David Jonassen (1985-88)
(see above, Pres. Elect)

Rhonda Robinson (1984-87)
Dept. of L.E.P.S.
Northern Illinois University
DeKalb, IL 60115 (815) 753-0464

Naomi Story (1985-88)
Maricopa Community Colleges
3910 E. Washington
Phoenix, AZ 85034 (602) 244-8355

John Wedman (1986-89)
313 Townsend Hall, U. of Missouri
Columbia, MO 65211
(314) 882-3828

1987 Review Board

1. Patti Baker
236 Rainseyer
Columbus, OH 43210

2. John C. Belland
260 Breenbrier Court
Worthington, OH
43085

3. Melvin M. Bowie
201 Peabody Hall
U. of Arkansas
Fayetteville, AR
72701

4. Carol Carrier
104 Burton Hall
178 Pillsbury Dr. SE
Minneapolis, MN
55455

5. Jeanette Cates
10502 Hardrock
Austin, TX 78750

6. Gayle Davidson
3326 38th Ave. S
Minneapolis, MN
55406

7. Francis M. Dwyer
458 Westgate Dr.
State College, PA
16803

8. Mike Hannafin
176 Chambers/PSU
University Park, PA
16802

9. John H. Joseph
PSU Capital College
Middletown, PA
17057

10. Barbara L. Martin
405 White Hall
Kent State Univ.
Kent, OH 44242

11. Tom Nielsen
346 Shades Crest Rd.
S. Birmingham, AL
35226

12. Alice Nuttall
77 Fir Hill-#11B12
Akron, OH 44304

13. Perrin E. Parkhurst
913 Whittier Dr.
E. Lansing, MI
48823

14. Timothy L. Phillips
310 Rackley Bldg.
University Park, PA
16802

15. Tillman Ragan
Univ. of Oklahoma
Collings Hall
Educ. Technology
Norman, OK 73019

16. James P. Randall
Dir., Media Services
School of Nursing
Widner Univ.
Chester, PA 19013

17. Lloyd Rieber
Pennsylvania State Univ.
302 Rackley Bldg.
University Park, PA
16802

18. Gregory C. Sales
608 Teackers College
ML002
Univ. of Cincinnati
Cincinnati, OH 45220

19. Wilhelmina Savenye
Curr. & Inst., EDB 406
U. of Texas at Austin
Austin, TX 78712

20. Michael R. Simonson
N031 Lagomarcino Hall
IRC
Iowa State Univ.
Ames, IA 50011

21. Patricia L. Smith
Curr. & Instruction
EDB 406
U. of Texas at Austin
Austiln, TX 78712

22. Michael J. Streibel
528 F. Teacher Ed. Bldg.
Univ. of Wisconsin
Madison, WI 53706

23. LeRoy J. Tuscher
Educational Tech. Center
301 Broadway Ave.
3rd Floor
Bethlehem, PA 18105

24. John F. Wedman
303 Townsend Hall
U. of Missouri
Columbia, MO 65211

25. Michael Williams
369 Laurel Ave. #205
St. Paul, MN 55102

26. Andrew R.J. Yeaman, PhD
Winter Hall 6053
College of Education
Dept. EF/CE
U. of Wisc/Whitewater
Whitewater, WI
53190-1790

27. David H. Jonassen
School of Education
60 McNutt Center
U. of North Carolina
Greensboro, NC
27412-5001

28. J. Randall Koetting
306 Gundersen
Dept. of Curr. & Inst.
Oklahoma State Univ.
Stillwater, OK
74078-0146

29. Dr. Rhonda S. Robinson
Northern Illinois Univ.
Leps - GA219
Dekalb, IL 60115

30. Dr. Catherine Fosnot
S. Conn. State Univ.
148 Davis Hall
New Haven, CT 06515

31. Gene L. Wilkinson
245 Carolina Ave.
Athens, GA 30606

Title:

"... Mere Vehicles ..."
A Symposium on the Status of Research in Instructional Technology

Symposium Leader:

Michael R. Simonson

Symposium Participants:

Richard Clark
James Kulik
Robert Tennyson
William Winn

". . .MERE VEHICLES. . ."

A Symposium on the Status of Research in Instructional Technology

SYMPOSIUM INTRODUCTION

Michael R. Simonson
Professor
College of Education
Lagomarcino Hall
Iowa State University
Ames, Iowa 50011

> "The best current evidence is that media are MERE VEHICLES that deliver instruction but do not influence student achievement any more than the truck that delivers our groceries causes changes in nutrition." (Clark, 1983, p. 445)

With the publication of this sentence one of the most interesting controversies in the history of educational media research began. Clark's article formally presented a position that for years had been the hidden fear of many in the media research community, the fear that media do not really contribute to learning, but merely allow for the storage and delivery of information that might then produce learning. Clark said what others feared, and he said it persuasively.

Basically, Clark presented the argument that media did not influence achievement in any predictable, generalizable way, and studies that reported that media alone, or in part, did produce learning gains were confounded in some way. Clark went on to support his position by carefully reexamining the considerable body of educational media research. His conclusions were so convincing that the focus of instructional media research shifted almost overnight, and many researchers began to reexamine their own position on the impact of media on learning and education.

All who read or heard about Clark's article were not pleased or in agreement with his arguments, however. Almost immediately a "howl of anger" was heard from many media professionals. The most immediate concerns were expressed by the many media practitioners, such as media center directors, who felt betrayed. Media programs and media specialists in schools and colleges had been experiencing a decade long period of decline and were looking for support from others in the profession, especially researchers, who they thought should publicize how necessary educational media were. These practitioners certainly did not appreciate Clark's widely publicized report that they thought said "media don't make any difference." Many expressed bewilderment over how "one of our own" could advocate a position considered to be detrimental to the "cause". Some even felt that Clark's article was a further demonstration of how far removed researchers were from the real world.

Of more significant interest, however, were the counter arguments presented by other highly regarded researchers. It became obvious very quickly that Clark's position was not universally held, even in the academic community. The first rebuttal to Clark's arguments came from Michael Petkovich and Robert Tennyson of the University of Minnesota. Their "critique" was published in 1984 in the EDUCATIONAL COMMUNICATIONS AND TECHNOLOGY JOURNAL (ECTJ), edited by William Winn. Their position was basically that ". . .Clark's conclusions are unwarranted . ." (Petkovich and Tennyson, 1984, p. 233). They took issue with many of Clark's arguments, and recommended that research on "media and learning continue" (p. 237). Interestingly, Editor Winn permitted Clark to "reply" to Petkovich and Tennyson in the same issue of ECTJ. Basically, Clark reiterated his position in his "reply".

With the publication of these new articles the pace of the controversy quickened and interest increased in the educational media research community. In many respects, sides were taken and battle lines were drawn.

During this same time period, James Kulik and his colleagues at the University of Michigan had been publishing the results of meta-analysis studies that reviewed research on computer based instruction. In general, Kulik's studies indicated that the computer had a significant positive influence on student learning. Clark took notice of Kulik's results and published a series of articles that examined Kulik's work, took issue with Kulik's conclusions, and reiterated his own position on the confounding of media research, including research on computer based instruction.

Again, the battle was joined. The JOURNAL OF EDUCATIONAL COMPUTING RESEARCH (JECR), and ECTJ published articles and rebuttals from Clark and from Kulik (Clark, 1985a; 1985b; Kulik, 1985). Clark's position was basically the same. He said that "any resulting change in student learning or performance may be attributed to the uncontrolled effects of different instructional methods, content, an/or novelty" (Clark, 1985a, p.137). Kulik, on the other hand, continued to report the results of meta-analyses that indicated the positive influence of computer based instruction on learning.

Presentations at Conferences and Conventions were made by both Kulik and by Clark, but not at the same time. The issue became so engrossing that a review editor for ECTJ felt moved to write an article discussing his reactions to the Clark article and why he recommended it for publication. This was a unique occurrence in the history of ECTJ (Cunningham, 1986).

As of the 1987 Association for Educational Communications and Technology Convention, the controversy continues. Neither position is universally accepted, although the arguments of both sides have received wide distribution and have attracted many advocates.

The intent of this symposium is to bring together the researchers who advocate the extreme positions on this matter, and to give them the opportunity to present their views. While resolution of the controversy may be impossible, it is hoped that the papers and discussions presented at this symposium will help "clear the air" on this issue. The symposium participants include:

Michael R. Simonson, Professor
Iowa State University

Simonson is the organizer of the symposium and will act as the symposium moderator. As the editor of the RTD/AECT Convention PROCEEDINGS, Simonson has been a long time observer of all four presenters.

Richard E. Clark, Professor
University of Southern California

Without Clark there would be no symposium because there would probably be no controversy. Although Clark himself has stated that the criticism of media research has a long history, he was the researcher who focused interest on this issue and who presented the "mere vehicles" argument concisely and convincingly.

William Winn, Professor
University of Washington

While it might be possible to categorize Winn as Clark's "second" in this duel, it would be a superficial generalization. Winn, editor of ECTJ, is like Clark, one of AECT's and media's most respected researchers. His work as editor has made him familiar with the status or research in our discipline, and apparently has made him an advocate with basically the same interpretation of this research as Clark.

Robert Tennyson, Professor
University of Minnesota

As a member of the team who first publicly disputed

Clark's position, and as a widely respected researcher, Tennyson brings to the symposium the unique perspective of one who has followed Clark's work, and who has considerable experience in educational media research.

James Kulik, Professor
University of Michigan

Kulik's excellent meta-analyses of research on computer based instruction have been widely distributed and cited by advocates of the positive impact of computers on learning. Kulik's efforts to synthesize results into some body of information that has meaning to practitioners as well as other researchers has been widely applauded by many in the profession, including Clark.

CONCLUSION

Following are the four papers prepared by the four researchers who participated in this symposium. These papers represent their current positions, and will clarify for the reader the impact media have on learning as this concept is understood by arguably the brightest and most knowledgeable minds in our profession. For, as Oliver Wendell Holmes said of reading the works of great thinkers:

> "Thus only can you gain the secret isolated joy of the thinker, who knows that, a hundred years after he is dead and forgotten, men who never heard of him will be moving to the measure of his thought - the subtle rapture of a postponed power, which the world knows not because it has no external trappings, but which to his prophetic vision is more real than that which commands an army."

REFERENCES

Clark, R.E. (1983). Reconsidering research on learning from media. REVIEW OF EDUCATIONAL RESEARCH, 53(4), 445-459.

Clark, R.E. (1985a). Confounding in educational computing research. JOURNAL OF EDUCATIONAL COMPUTING RESEARCH, 1(2), 137-148.

Clark, R.E. (1985b). Evidence for confounding in computer-based instruction studies: Analyzing the meta-analyses. EDUCATIONAL COMMUNICATIONS AND TECHNOLOGY JOURNAL, 33(4), 249-262.

Clark, R.E. (1986). Absolutes and angst in educational technology research: A reply to Don Cunningham. EDUCATIONAL COMMUNICATIONS AND TECHNOLOGY JOURNAL, 34(1), 8-10.

Cunningham, D.J. (1986). Good guys and bad guys. EDUCATIONAL COMMUNICATIONS AND TECHNOLOGY JOURNAL, 34(1), 3-7.

Kulik, J.A. et.al. (1985). LETTERS-The importance of outcome studies: A reply to Clark. JOURNAL OF EDUCATIONAL COMPUTING RESEARCH, 1(4), 381-386.

Petkovich, M.D. and Tennyson, R.D. (1984). Clark's "Learning From Media": A critique. EDUCATIONAL COMMUNICATIONS AND TECHNOLOGY JOURNAL, 32(4), 233-241.

WHICH TECHNOLOGY FOR WHAT PURPOSE?:

The State of the Argument About Research on Learning from Media

Richard E. Clark
University of Southern California

Symposium paper for presentation at the annual convention of the Association for Educational Communication and Technology, Atlanta Georgia, Thursday, February 26, 1987.

Arguments that media do not influence learning have a very long but largely ignored history. Over sixty years ago, Freeman (who is quoted in Saettler's history of educational technology) cautioned against media comparison studies. In the years since, his advice has been elaborated on by researchers such as Wilbur Schramm, Pat Suppies, Kieth Mielke, Howard Levie and Gavriel Salomon. My own contribution to the argument has been minor. When one considers the weight of evidence against media comparisons, one quickly comes to the conclusion that the continuing argument indicates a considerable resistance to the evidence. I reasoned that the problem was not in the research reviews but in the communication between researchers and practitioners. My small contribution was to provide what I hoped were meaningful and accurate analogies (e.g. the grocery truck and nutrition analogy plus the inert medium for drugs and body chemistry analogy). I also avoided the "tentativeness" one typically finds in the reviews of responsible researchers. It seemed to me then (and now) that media enthusiasts interpreted our cautious writing style as the sign of a weak argument. Therefore, I used more active prose to suggest that "...media do not influence learning under any conditions." (1983, p. 445).

As might be expected, there is still considerable resistance to this reasonable interpretation of sixty years of research. One measure of the resistance is to be found in my mail over the past five years. I have received a surprising volume of letters charging me with providing support and comfort to the enemies of media in education and training. More important is the fact that some people mistakenly believe that I have a dispute with Jim Kulik and his colleagues at the University of Michigan about meta-analytic techniques. Equally important is the impression that I am somehow "against" media. I'd like to use this fairly informal Proceedings format to dispel all three misconceptions.

A Brief Restatement of the Media and Learning Argument. Basically I have made two arguments: first, that media comparison studies show no differences in learning attributable to any one medium over another; and second, that the so-called media attribute argument is not supported by current cognitive research.

The first argument that media comparison studies are usually confounded is rarely disputed by people who have specialized in media research. This confounding shows up in many ways. One of the most dramatic can be found in the current meta-analyses of CBT research. The clue to the confounding in research can be found in studies where the same teacher or designer produces both the computer and the "traditional" treatment. The effect size in these studies is usually smaller. I have argued that there is compelling evidence that this smaller effect is due to increased chances that the same content and method will be used in both the traditional and the CBT presentations -- which leads to no statistical difference in the learning between the two types treatments. Of course this control is not automatic. Some of the "same teacher" studies have poor controls just as studies where treatments were designed by different groups sometimes have good controls. In a recent survey of a 30% sample of the college CBT studies meta analyzed by Kulik and his colleagues, I separated well controlled from poorly controlled studies (Clark, 1985a, 1986). The effect size in well-controlled studies fell to .09 standard deviations in favor of CBT. This low effect size, I suggested, would be even lower if low ability learners had received more practice using computers before studies started. More recently, Levin (1986) has provided a similar meta-analysis ~~adequate~~ of CBT cost-effectiveness research. He finds CBT effect sizes ranging from .12 for mathematics to .24 for reading -- which is within the range of my analysis. Levin and I have estimated effects considerably lower than the .4 to .5 effect sizes reported by Kulik and his colleagues. The difference between the research Levin and I have analyzed and the studies used by Kulik is simply a different set of criteria for control. Kulik is correct in his claim that there is a very powerful set of instructional methods used in the development of CBT. I would like to have us examine those methods separately from their confounded attachment to the medium of Computers.

While Kulik and I had some early discussions about our separate findings, we have since agreed -- as Kulik et al nicely put it -- that in comparison studies there is a "...diffusion of the innovative treatment to the control condition.", (1985, p. 385). In more direct terms, we agree that there are uncontrolled content and instructional methods in many computer-based training and "control" treatments which account for learning gains. These methods can "diffuse" or be delivered by live teachers or older, more traditional media. I have urged researchers and practitioners to focus on an explication of these instructional methods if we wish to understand what causes the large effect sizes one finds in CBT studies (Clark, 1985b)

Media Attribute Research. The argument about the media attribute theories is not so easy to dismiss. I have disputed the theory that different media contribute to learning by providing "attributes" that cultivate cognitive skills. For example, in one of Gavriel Salomon's well-known studies, "zooming" into details cultivated the skill of "cue attendance" for low ability students. While Salomon has clearly noted that these attributes are not specific to any one medium, his theory has mistakenly been associated with the argument about the "contribution" of media to learning. Salomon and I reviewed the evidence in our recent Handbook chapter (1986) and noted that the dispute is part of a much wider argument between two factions in cognitive psychology. I have noted that no one has ever established that any attribute which is specific to one medium or class of media is "necessary" to learn any specific cognitive skill (Clark, 1983). Whenever one finds an attribute -- such as zooming into details or rotating visual forms or ways to depict three dimensions -- it will always be the case that other, different attributes or presentation forms will teach the same cognitive skill. If this claim is correct, then one must conclude that media attributes are interchangeable and make no necessary psychological contribution to learning.

Remaining Disputes

Media Attributes. Of course, there are still grounds for reasonable dispute about media attribute theories. Bob Kozma, at the University of Michigan, has provided a summary of an alternative point of view in a recent ECTJ article (Kozma, 1986). He ~~Kozma~~ notes that specific media attributes do not have to be necessary to be important for learning -- a reasonable point. Yet he still argues that some media might have unique "mixes" of attributes and therefore be "powerful" and make a "unique" contribution to learning. This seems to me to beg the question but I'm eager for Kozma to be more specific about which mix and what medium. He and I have been collaborating on the development of this argument and are committed to continue to work together until we have resolved the problem.

Is Media Useful in Education and Training? The remaining issue is much more emotional and less tangible. If one reaches the conclusion that media make no necessary psychological contribution to learning outcomes, can one then support the use of media in education and training? The answer to this question is, I think, a very enthusiastic "yes". My research has been directed to dispelling misconceptions about the psychological contribution of media. On a different level, there is considerable evidence that the benefits to be derived from media are primarily economic. That is, different types of media have the potential of saving a significant amount of instructional development, learning and delivery time and money. Economic savings are available both in large instructional systems and on a more personal level to the writer and researcher.

Media also have the potential to greatly increase the reliability or consistency of instructional technology. The direct benefit to psychological research are also obvious to most of our colleagues. Various delivery media have been used as productive analogies of human perception and thinking. The computer serves as the model of the human learner which dominates the new and exciting cognitive psychology. The medium of Laser Holography has helped Carl Pribram at Stanford understand the mysterious capacity of the brain to distribute long-term memory store throughout the brain and make it more or less impervious to erasure. While media will continue to serve as analogies of human cognitive and perceptual processes, the most productive future research will probably deal with efficiency questions.

Recent Studies of the Economic Benefits of Media. While there have been many recent studies of the economic benefits and pitfalls of media, one of the most thorough and important is the recent, yet unpublished review by Henry Levin at Stanford University (November, 1986). He has reanalyzed a number of recent, comprehensive CBT cost-effectiveness studies. His conclusions, presented only briefly here, note that CBT cost-effectiveness (C/E) is relatively poor in most evaluation studies. However, when sites make a determined effort to promote full utilization of the medium and the software, C/E increases by a factor of 50 percent. Most important for media managers is Levin's finding that there are dramatic C/E differences for the came CBT programs between implementation sites. That is, when the same CBT program is implemented in different schools or cities, the C/E ratio changes by as much as 400 percent! This strongly suggests the importance of management systems for implementing and directing the use of CBT systems. Levin's study also provides many important cautions for the researcher and the practitioner communities. To date he has located about 80 large-scale CBT evaluation studies where costs and time were assessed. Yet, his attempt to include only adequate studies in his analyses excluded all but eight from his final analysis. It seems that we should be wary of basing research or implementation decisions on any arbitrarily selected subset of this flawed literature. Levin's description of what he calls the CBT "implementation" issue should be required reading for all media researchers. He notes, for example, that elementary school computer systems tend to be more fully utilized than those in secondary or college settings -- which may account for the typically larger achievement effect sizes found in the meta-analyses by Kulik and others.

We should, I think, welcome the increased media research collaboration of outstanding economists such as Levin. It seems that the practical payoff available to education and training from media is primarily economic and administrative. If we can encourage more rigorous cost-effectiveness research, we will know better how to make the best use of newer systems.

The Social and Political Context of Media Use. Of course, even when we find the most efficient way to deliver instruction in various settings there will always be barriers to implementation. In this regard I have been influenced by the scholarship of Bob Heinich at Indiana University (1985). Heinich cautions us that education is a "labor intensive" activity which is dominated by powerful teachers unions. He recommends increased research interest on questions dealing with the social and political barriers to media implementation. In the context of Levin's cautions about "full implementation", Heinich seems to be pointing to a potentially significant barrier which needs to be understood better. What is desperately needed here is objective and scholarly studies of the social and political context of change in the delivery of instruction. We have ample examples of polemics about "teacher resistance" and "Luddite" thinking in reference to media. The cause of the conflict may stem from an impending revolution in our profession.

A Confusion of Technologies. One basic problem in our past thinking about media seems to me to have been a confusion about which technology was serving what purpose. Heinich's (1985) reminder that technology is best interpreted as the "application of a science" to solving practical problems is a critical point. In our field we too often mean "machine" when we use the term technology. Actually, the machines we call media are the result of communication technology i.e. they are the consequence of the sciences dedicated to describing the transportation of information. One of the eldest and closest scientific relatives of communication science is economics. Information theory was the offspring of a marriage between "Ma Bell" and a few crusty mathematicians. Essentially, it had its origin in the search for more efficient ways to send more signals with greater fidelity over fewer telephone cables. One resulting technology called media solves problems related to the efficiency of transporting or "delivering" information (this is the origin of the grocery truck and nutrition analogy). However, delivery technology does not solve psychological problems. The "science" of psychology is applied in the technology of instructional design. Here we deal with issues of, for example, the psychological consequences of different task, individual difference and instructional method variables. When we confuse the two technologies and, by extension, their underlying sciences -- we design confounded research.

CONCLUSION

A Confusion of Craft with Technology. The final point to be raised in this paper seems to me to be the most important of all. The origin of the resistance to media research and the confusion of technologies is part of a larger and more serious dispute in our field. The real conflict is between an older "craft" oriented approach to media and newer scientifically-based technologies. The craft approach typifies much of teacher education and practice, some of the media enthusiasms, and (sadly) even a few of our university departments and professors of "educational communications, systems and technology". The differences between the two approaches are profound and the decision about which point of view will dominate may be the most important determiner of the future of our field (Clark, 1987).

Craft approaches are based on the assumption that problems can be solved with procedures which have evolved over time as a result of "expert" experience. When a craft dominates a teaching activity, the curriculum consists of procedures which are suspected to have solved problems in the past. Yet, these procedures seldom are applicable to future problems and a craft cannot easily adjust to changes. John Dewey's attraction to science as a way of solving educational problems stemmed from his concern about our failure to provide educators with effective and flexible strategies for teaching. As a result, he wrote, the teacher must "... fall back upon mere routine traditions of school teaching, or to fly to the latest fad [or] panacea peddled out in school journals or teacher's institutes -- just as the old physician relied upon his magic formula." (Dewey, 1900, p. 113). There are simply too many "magic formula's" around today in the media area. Too many unfounded assumptions and procedures for guiding instructional design and delivery. Many of these assumptions are demonstrably wrong but since there is little attempt at objectivity, the same mistakes are repeated over and over without correction. It is the nature of a craft to notice what fits our expectations and ignore what does not. This strategy seems to maintain our self esteem in unimportant personal matters but it makes a mess of our professional contributions.

Barbara Ward, the great historian and sociologist, has warned that the difference between craft and science-based technology is as profound as the most fundamental difference between primitive and advanced societies. The backward dependence on craft when technologies are available is, I think, one of the most important roots of the difficulties being experienced in the past few years by AECT. The commitment to research and researchers in this organization has always been tentative and reluctant. Enthusiasm for the newest media fad and panacea has been the dominant theme of this organization for the two decades that I have followed its activities. People with a strong commitment to and training in research have seldom held responsible positions in AECT. When they do they typically report a considerable lack of interest on the part of many powerful members to support a research focus for the entire organization. One current consequence of this attitude has been the recent failure to support our research journal, ECTJ, even though it has always made more money than it costs to publish.

While I am reluctant to suggest a solution to AECT's problems, I do think that media researchers need to orient themselves much more towards their "parent" social science disciplines. We can not continue to conduct our research with the same set of values which have driven the media enthusiasms of the past. If one is interested in instructional design for computer-based training for example, then it is imperative to master and follow the research and theory developments in instructional psychology. Specialists in media delivery should monitor relevant economics and organizational research. Those interested in the types of problems raised by Bob Heinich should make a commitment to master research in sociology, social-psychology and/or political science. What will connect us all is a common thread of scientific methodology, a commitment to developing a "linking science" (as Dewey suggested), and an abiding interest in contributing to the future development of instructional research, theory and practice.

REFERENCES

Clark, R. E., (1983), Reconsidering research on learning from media, Review of Educational Research, 53(4), 445-460.

Clark, R. E., (1985a) Confounding in educational computing research, Journal of Educational Computing Research, 1(2), 137-148.

Clark, R. E., (1985b), The importance of treatment explication: A reply to J. Kulik, C-L. Kulik and R. Bangert-Drowns. Journal of Educational Computing Research, 1(4), 389-394.

Clark, R. E., (1986), Evidence for confounding in computer-based instruction studies: Analyzing the meta-analyses. Educational Communication and Technology Journal, 33(4), 249-262.

Clark, R. E., (In press, 1987), The future of technology in educational psychology, In Wittrock, M. C. and F. Farley (Eds), The Future of Educational Psychology. Hillsdale, N.J.: Lawrence Earlbaum Publishers.

Clark, R. E. and Salomon, G. (1986), Media in teaching, In Wittrock, M.C. (Ed), Handbook of Research on Teaching: Third Edition. N.Y.: MacMillan.

Dewey, J. (1900) Psychology and social practice. The Psychological Review, 7, 105-124.

Heinich, R. (1985) Instructional Technology and the structure of education. Educational Communication and Technology Journal. 33(1), 9-15.

Kozma, R. B., (1986), Implications of instructional psychology for the design of educational television, Educational Communication and Technology Journal. 34(1), 11-19.

Kulik, J., Kulik, C-L., and Bangert-Drowns, B. The Importance of outcome studies: A reply to Clark. Journal of Educational Computing Research, 1(4), 381-387.

COMPUTER-BASED INSTRUCTION:
WHAT 200 EVALUATIONS SAY

James A. Kulik & Chen-Lin C. Kulik

Center for Research on Learning and Teaching
The University of Michigan
Ann Arbor, Michigan 48109

Many people believe that computer technology will change society in the years ahead as completely as the invention of the printing press did 500 years ago or as the invention of writing did thousands of years ago. These earlier inventions gave people new ways of encoding, storing, and retrieving information, and they ultimately changed the way people worked, the way they played, and probably even the way they thought. Computers have also given us a radically different way of handling information, and so it seems inevitable that they too will dramatically alter the way we lead our lives.

Educational researchers and developers therefore are no longer asking *whether* a computer revolution will occur in education. They are asking instead *how* it will occur. Will the changes in education come swiftly and smoothly, or will education's transition to the computer age be full of false starts and costly mistakes? How long will it take for educators to start using the computer well?

During the past two decades, hundreds of educators and evaluators have examined the effectiveness of programs of computer-based teaching. We joined this effort because we believe that adapting to the computer age is one of the major challenges facing schools today and that evaluation studies can help schools meet this challenge. Our approach was to analyze statistically, or meta-analyze, findings from as many evaluation studies of computer-based instruction as we could find. Our purpose was to provide teachers, researchers, and policy makers with an overview of what educators have accomplished to date with computer-based instruction.

We carried out four separate statistical analyses of findings on computer-based instruction (Bangert-Drowns, Kulik, & Kulik, 1985; C. Kulik & Kulik, in press; C. Kulik, Kulik, & Shwalb, 1986; J. Kulik, Kulik, & Bangert-Drowns, 1985). These analyses covered a total of 199 comparative studies: 32 in elementary schools; 42 in high schools; 101 in universities and colleges; and 24 in adult education settings. Each of the 199 studies included in our analyses was a controlled, quantitative study that met our predefined standards for methodological adequacy. The studies covered use of the computer in (a) computer-assisted instruction, or CAI, including drill-and-practice and tutorial instruction; (b) computer-managed instruction, or CMI; and (c) computer-enriched instruction, or CEI, including the use of the computer as a calculating device, programming tool, and simulator.

Overall Results

Most of the studies reported that computer-based instruction has positive effects on students.

1. Students generally learned more in classes in which they received computer-based instruction. The average effect of computer-based instruction in all 199 studies was to raise examination scores by 0.31 standard deviations, or from the 50th to the 61st percentile.

2. Students also learned their lessons with less instructional time. The average reduction in instructional time in 28 investigations of this point was 32%.

3. Students also liked their classes more when they received computer help. The average effect of computer-based instruction in 17 studies was to raise attitude-toward-instruction scores by 0.28 standard deviations.

4. Students developed more positive attitudes toward computers when they received help from them in school. The average effect size in 17 studies on attitude toward computers was 0.33.

5. Computers did not, however, have positive effects in every area in which they were studied. The average effect of computer-based instruction in 29 studies of attitude toward subject matter was near zero, and the average effect was also near zero in 23 studies of course withdrawals.

Study Features and Outcomes

A few study features were consistently related to outcomes of computer-based education.

1. Study results were consistently stronger in published studies and weaker in unpublished ones ($p < .01$). The average effect of computer-based instruction in published studies was to raise student examination scores by 0.46 standard deviations, whereas its average effect in unpublished studies was to raise scores by only 0.23 standard deviations.

2. Effects were larger when different teachers taught the experimental and control groups ($p < .05$). Effects were smaller when the same teacher was responsible for both groups. With the same teacher in charge of experimental and control groups, average size of effect on examination scores was 0.24 standard deviations. With different teachers in charge of the groups, the average effect was 0.40 standard deviations.

3. Effects tended to be larger in more recent studies and smaller in older studies ($p < .05$). The average effect of computer-based instruction in studies published before 1975 was to raise examination scores by 0.24 standard deviations; the average effect in studies published in later years was a score increase of 0.36 standard deviations.

4. Effects were also somewhat larger in short studies and weaker in longer ones ($.10 < p < .20$). The average effect of computer-based instruction in short studies was to raise examination scores by 0.36 standard deviations, whereas its average effect in longer studies was to raise scores by 0.27 standard deviations.

Because study features were moderately intercorrelated, multiple regression analyses were carried out on study feature data. In the multiple regression equation developed from the full data set, three of the four study factors had significant weights: publication source, control for instructor effects, and study duration. The regression weight for the fourth study feature—study year—reached a borderline level of significance.

Discussion

Why have evaluations of computer-based instruction produced such positive results? Several different factors might have contributed to the favorable picture in the literature:

Editorial gatekeeping. Journal editors and reviewers may prefer to publish strong and significant results rather than weak and insignificant ones.

Experimental design flaws: Design flaws in evaluation studies may allow researcher biases and expectations to color study results.

Instructional quality: The positive results from meta-analytic studies may reflect real differences in the quality of conventional and computer-based instruction.

Editorial Gatekeeping

If editorial gatekeepers base their publication decisions on the significance of study findings rather than on study quality, then published studies provide a distorted picture of what actually works in education. In such a case, an educator could get a better picture of what works from the clearinghouse literature, the dissertation literature, or—better yet—the file-drawer and wastebasket literature. The poorest guide to what works would be the most highly peer-reviewed literature.

Before throwing away the most respected literature in education, however, we should consider another possibility. The difference in results in published and unpublished reports may have another cause. We should remember that the authors of journal and dissertation studies are different individuals working under different circumstances. They differ in their research experience, in their resources, in their relationship to instructional developers, and in many other respects. Such differences can explain—just as well as editorial gatekeeping can—the differences in results found in dissertations and journals. It seems to us that we know too little about what lies behind the difference in journal and dissertation results to reject out-of-hand either kind of result.

Experimental Design

Can flaws in experimental design explain—or explain away—the positive findings from studies of computer-based instruction? Some reviewers think so. They believe that with imperfectly controlled experiments, positive results are more likely to occur than negative ones. Among the factors that might distort results in an imperfectly controlled evaluation are differences in time-on-task, self-selection differences in assignment to comparison groups, and uncontrolled teacher effects.

The evidence from our meta-analyses is that not all such factors are important. The positive results of evaluations of computer-based instruction cannot be attributed to differential time-on-task for comparison groups, for example. Studies that control for time-on-task have produced nearly the same results as studies without strict controls on instructional time. Actual records of instructional time have been collected in several studies, and these records suggest that students in computer groups often receive instruction for shorter periods than conventional students do.

Probably no other methodological point has received as much attention in evaluation research in recent years as the distinction between random experiments and quasi-experiments. Random experiments are generally thought to produce clear and consistent results; quasi-experiments are often thought to produce inconsistent and biased results. In our meta-analyses, random experiments and quasi-experiments produced the same results. Our meta-analytic results did not support the idea that the nature of subject assignment to groups is an important methodological flaw in evaluation studies of computer-based instruction.

Results from studies with and without controls for instructor effects are somewhat different, however. In the typical study with the same instructor teaching experimental and control classes, the effect of computer-based teaching seemed modest. In the typical study with different instructors in experimental and control classes, the effect of computer-based teaching seemed more substantial.

Why should one-instructor and two-instructor experiments produce somewhat different results? It is not at all obvious to us. It may be, for example, that in two-instructor experiments, the poorer instructor is usually assigned to the control condition and the better instructor to the experimental condition, and the difference between conditions is magnified because of these teacher assignments. If this is the case, then one-instructor studies more accurately assess the effects of computer-based instruction. It may also be, however, that in one-instructor studies there is diffusion of the innovative treatment to the control condition. Involvement of a teacher in an innovative approach to instruction may have a general effect on the quality of the instructor's teaching. Outlining objectives, constructing lessons, preparing evaluation materials, and working with computer materials—requirements in computer-based instruction—may help a teacher to do a better job in a conventional teaching assignment. If this is the case, two-instructor studies provide the better basis for estimating the size of an experimental effect.

Instructional Design

Computer-based instruction is often well-designed instruction. The hard work of an instructional design teams often ensures the quality of computer materials. Objectives are usually clear and explicit. Instruction is carefully sequenced. The materials engage the learner's attention and encourage learner activity. The program provides frequent feedback to the learner. Instructional design teams often spend 100 hours developing just one hour of computer lessons.

Certain features of the computer make it an especially attractive medium for instructional designers. Computers can generate attractive and complex graphics quickly. Computers can simulate motion. They can give undivided attention to a single learner. They can provide complex evaluations of a learner's performance. They can wait patiently. They can be programmed to model a learner's cognitive processes.

In certain respects, computer lessons seem to have an advantage over lessons presented by classroom teachers. Few classroom teachers can put 100 hours of preparation time into each one-hour lesson. Classroom teachers cannot give each individual in a large classroom their continuous, undivided attention. Classroom teachers can be notoriously slow at grading student work and preparing reports. And their patience is often tried by their students.

Can such differences account for the superior record of computer-based instruction in evaluation studies? They might. It is possible that the computer has fared so well in evaluation studies because programs of computer-based instruction have generally been well-designed, and computers have delivered instruction in an attractive and engaging way. It is possible, in other words, that we should take the findings of studies of computer-based instruction at face value, and conclude that the computer has so far been an excellent vehicle for the delivery of instruction.

Conclusions

Among the conclusions that can be drawn from our analysis, the following three seem especially important to me:

1. Most programs of computer-based instruction evaluated in the past have produced positive effects on student learning and attitudes. Future programs for developing and implementing computer-based instruction should therefore be encouraged. If such programs are as carefully designed as current programs are, they will most likely produce positive results.

2. Both journal articles and dissertations present a basically positive picture of results of computer-based instruction, but the findings reported in journal articles are clearly more favorable. Researchers should give high priority to finding out what factors produce differences in journal and dissertation results. Does editorial gatekeeping lead professional journals to present a distorted picture of social science findings? Or do dissertation authors simply measure experimental effects less well than do more seasoned researchers?

3. Although a variety of different research designs can be used to show the effectiveness of computer-based instruction, certain research designs seem to produce more positive results. Studies where the same instructor teaches both experimental and control classes, for example, report somewhat weaker effects than do studies with different experimental and control teachers. Studies of long duration often report weaker effects than do short studies. Reasons for the difference in results from studies using different experimental designs are not well understood, however. Research on such factors should be encouraged.

References

Bangert-Drowns, R. L., Kulik, J. A., & Kulik, C.-L. C. (1985). Effectiveness of computer-based education in secondary schools. *Journal of Computer-Based Instruction, 12,* 59–68.

Kulik, C.-L. C., & Kulik, J. A. (1985). Effectiveness of computer-based education in colleges. *AEDS Journal.*

Kulik, C.-L. C., Kulik, J. A., & Shwalb, B. J. (1986). Effectiveness of computer-based adult education: A meta-analysis. *Journal of Educational Computing Research, 2,* 235–252.

Kulik, J. A., Kulik, C.-L. C., & Bangert-Drowns, R. L. (1985). Effectiveness of computer-based education in elementary schools. *Computers and Human Behavior, 1,* 59–74.

Computer-Based Enhancements for the Improvement of Learning

Robert D. Tennyson

University of Minnesota
Department of Educational Psychology
178 Pillsbury Dr. S.E.
Minneapolis, MN 55455

January 22, 1987

Presented in the symposium, "...Mere Vehicles...": Discussion of What the Research Says by Those Who are Doing the Saying, Chair, Michael R. Simonson, at the annual meeting of the Association for Educational Communication and Technology, Atlanta, GA (February, 1987).

Computer-Based Enhancements for the Improvement of Learning

Robert D. Tennyson
University of Minnesota

For the past 20 years a major debate in the field of educational technology has been the two part question: "does media improve learning?", and if so, "by how much?". Early on, proponents of an affirmative answer based their opinions solely on technocratic assumptions. This group is still alive today but with increased support form the hard technologists (i.e., computer scientists) which offer such "new" technologies as microworlds, "intelligent" computer-assisted instruction (ICAI), and expert systems. Those educators who answered with a negative, based their conclusions basically on methodological grounds. They argued first that research findings in favor of the question were flawed in both experimental design and methodology. Given the academic approach to their criticism, the opponents only achieved recognition in a limited circle of educationally based research programs. And, with the rapid development of computer technology following the application of the mirco-clip in the later 1970s, the questions no longer seemed relevant. That is, it was assumed to have been answered in the affirmative by the advancement of technology.

However, by the mid-80's, educators by increasing numbers began to realize that maybe the question needed to be reconsidered given the apparent decline in computer popularity as the solution to the crisis in education. Once again though, the technologist have been successful in fending off the opponents because of several hardware (e.g., interactive video) and software (e.g., LOGO) developments. But, as the new technological "solutions" continue to fail or to be replaced by yet another educational panacea, opponents are still raising the question a new. And as the new technologies become even more sophisticated, the question is actually becoming more important.

The purpose of this presentation is not an answer to the question, but to elaborate on the question and to offer a view that is at the same time a yes and a no. The problem seems not to be the technology, but the failure of proponents to adequately trace the variables of their respective media techniques to clearly defined learning processes. For example, LOGO is suppose to improve thinking skills simply because the student is engaging in a technology-based discovery system. Although proponents of LOGO claim some foundation in neo-Piagetian learning theory, they, for the most part, have invented a set of terms beyond the scope of Piaget's theory which focuses on experience and effort in learning. Piaget emphasized active engagement in the domains of information, not artificial environments divorced from real knowledge.

To illustrate this concept of tracing media-based variables to the improvement of learning, I will concentrate on the program of research that my colleagues and I have been working on since 1971. There are of course other researchers and centers of programmatic research which further illustrate this concept of media research founded in learning theory: for example, Joseph Scandura, Robert Glaser, David Merrill, Paul Merrill, Richard Clark, Steve Ross, and Gabriel Solomon.

Tracing Model

In this article I will discuss six basic educational components necessary to trace media variables directly to specific learning processes. Because of the focus of my research on computer-based variables, I will not include other media forms (e.g., video and print). The purpose of this article is not to explain in detail all of the components, but to propose that an answer to the question on media and improved learning can be done in part by showing the direct of linkage media variables to specific learning conditions and processes.

Information processing model of learning. In my research program, the basic learning theory is directly related to a information processing model. This model has been defined in several sources (Tennyson, 1978; Tennyson, in press; Tennyson & Christensen, 1987). The model includes these system components (Figure 1): (a) the receptor component by which external information is entered into the brain; (b) the perception component where the information is filtered according to individual criteria; (c) the short-term/working memory component which has a dual function. The short-term memory deals only with information at the given moment and does so with no cognitive effort for encoding. Working-memory on the other hand engages directly with long-term memory to encode information into the current knowledge base; (d) the long-term memory component which consists of the storage and retrieval systems. The storage system codes information according to specific types of knowledge (i.e., declarative, procedural, and conceptual) while the retrieval system involves the thinking skills associated with differentiation and integration; and (e) the cognitive process of creating knowledge within the cognitive system itself.

Insert Figure 1 about here

Components of Tracing Model

Table 1, shows the six main components usually associated

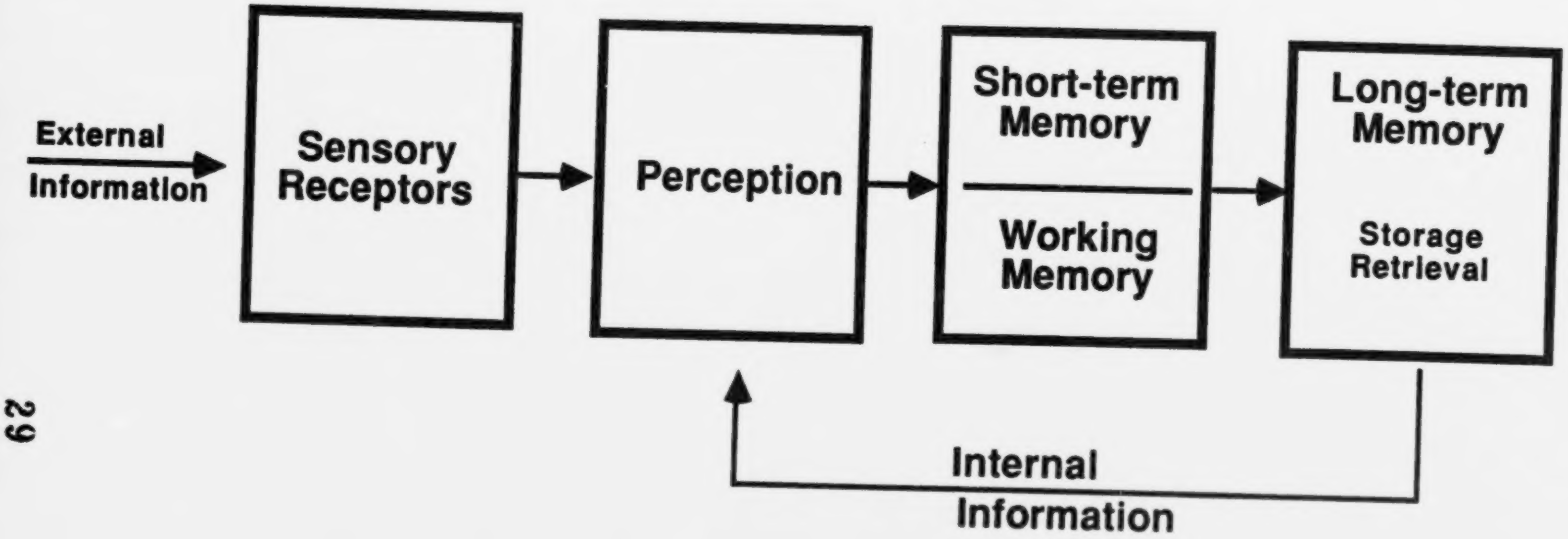

External
Information
Sensory Receptors
Perception
Short-term Memory
Working Memory
Long-term Memory
Storage
Retrieval
Internal
Information

Figure 1. Meta-Learning Model.

with the instructional design (ID) process. In practice, however, the links between the components are neither well established operationally or theoretically. My purpose here is to both illustrate and discussion the linkages to propose that media can improve learning when it is viewed as an integral component of the entire ID process.

Insert Table 1 about here

The six components are:

-Learning Processes. The focus here is on the long-term memory systems of storage and retrieval. Storage system refers to the learning processes associated with knowledge acquisition (i.e., the encoding and coding of information) while retrieval system refers to the skills of thinking (i.e., recall, problem solving, and creativity).

-Learning Objectives. The purpose of education is to result in student learning (i.e., knowledge acquisition and thinking skill development). Objectives are necessary to identify the type of learning that is desired. The objectives should be linked to specify learning processes.

-Knowledge Base. Analyzing the information to be learned involves not only the basic content but also the structure of the information as knowledge in memory.

-Instructional Variables. The means of instruction are the variables by which information is communicated to the student. In Table 1, I present those basic variables which have been empirically tested to improve learning. The variables are directly linked to their respective primary learning processes. Certain variables may also have secondary links to other processes.

-Instructional Strategies. The instructional strategies identified here only represent those which I have tested in my research program. And, in most situations, employed computers in some capacity.

-Computer-Based Enhancements. The enhancements listed here are sub-divided into categories according to their intelligence in decision making. Conventional computer-based instruction (CBI) uses branching techniques that are determined in the design stage and are preset in the program. Intelligent CBI are rule-based programs that make decisions at moment the student is learning: Thus, they adjust moment to moment to individual differences.

Tracing declarative knowledge. In general terms,

Table 1: Tracing Learning Processes to Computer-Based Enhancements

Learning Processes (Long-Term Memory)	Learning Objectives	Knowledge Base	Instructional Variables	Instructional Strategies	Computer-Based Enhancements	
STORAGE SYSTEM:					CONVENTIONAL (branching)	INTELLIGENT (rule-based)
Declarative Knowledge (knowing what)	Verbal/Visual Information (awareness and understanding of concepts, rules, & principles)	Schema Characteristics (content: objects, events, & situations)	Label Definition Best Example Refreshment Expository Examples	Drill & Practice (e.g., rhearsal, repetition) Lecture	Replacement Ratio Worked Examples Graphics	Embedded Refreshment & Remediation Mixed Initiative Advisement
Procedural Knowledge (knowing how)	Intellectual Skills (ability to employ concepts, rules & principles)	Schema Structure (context organization: algorithm or heuristic)	Interrogatory Examples (divergent) Attribute Elaboration	Tutorial (e.g., PI, CAI, ICAI, peer tutor)	Format of Examples	Amount of Information Learning Time Corrective Error Analysis Sequence of Information Process Feedback
Conceptual Knowledge (knowing when and why)	Conditional Information (ability to perceive criteria, values & appropriateness)	Schemata Structure (network associations & rules: taxonomy, category, & hierarchy)	Context (problem) Advanced organizer Feedback Strategy Information Cooperative Learning Group Techniques (heterogeneous)	Task-Oriented Simulations	Adjustment of Variables & Conditions	
RETRIEVAL SYSTEM						
Differentiate Integrate Create	Cognitive Strategies (Develop skills in recall, problem solving, & creativity)		Cooperative Learning Group Techniques (homogeneous)	Problem-Oriented Simulations		Elaborateation & Extension of Variables & Conditions

declarative knowledge means "knowing what." For example, the student knows that underlining keywords will improve recall. The learning objective for this learning process is verbal/visual information. What the student learns is both an awareness and understanding of concepts, rules and principles. For example, the student is aware of certain strategies for recalling of information from text. The knowledge base (KB) in my context employs a schema theory application. With this form of learning, the KB identifies the schema characteristics of the knowledge. Characteristics include the objects, events, and situations of a schema. For example, the student has a schema of underlining keywords of scientific text.

The instructional strategies for improving this learning process include variables directed to information that is specific, and perhaps, finite. The variables label and definition provide the location and connection of information in a KB. When a connection is difficult to establish, the refreshing variable focuses on the need for review of appropriate necessary knowledge. To initialize knowledge, the expository presentation of examples establishes a clear case of the content. This is especially important in the learning of complex rules and principles. Instructional strategies of drill and practice help the learner in acquiring the awareness of specific information with an expository presentation (e.g., a lecture) clarifying the understanding. The conventional computer-based enhancements provide for the optimal pacing and display of information while the intelligent enhancements keep the student directly involved with understanding the information to be learned. For example, the mixed-initiative variable allows the student to ask the system a question. Advisement keeps the students informed of their learning progress and needs.

Tracing procedural knowledge. Procedural knowledge is "knowing how." For example, the student knows how to use the APA Publication Manual in the writing of scientific text. The learning objective refers to this process as an intellectual skill, in which the students learn how to employ concepts, rules and principles. The KB here identifies the organizational structure of a given schema. For example, the student knows how to use the heuristics necessary to conduct experiments in educational research. The organization of a schema can take many forms, for example an algorithm or strategy used in searching through a data-based retrieval system.

The primary instructional variables at this level focus on practice of the information in problem or interrogatory situations. Examples should be selected to provide a wide range of applications. Divergent examples allow the students to elaborate on their KB. Tutorial instructional strategies provide a convenient method of interaction between the student and the tutor, be it either a human peer tutor or a computer-based tutor. The basic format is question/answer with the tutor challenging the student to clearly employ knowledge to prevent or eliminate misconceptions.

It is with this instructional strategy that the most dramatic advancements in computer-based instruction have been made in the last ten years. The variables listed in Table 1, are all part my research program the MAIS (Minnesota Adaptive Instructional System). The MAIS is a complete intelligent instructional system with an expert tutor monitoring student learning at all levels of learning. Variables monitored by the MAIS include the amount of information, learning time, sequence of information, feedback, and corrective error analysis. In fact, the MAIS implements all of the enhancements listed in Table 1. Additionally, all of the enhancements have been empirically tested in both laboratory and applied environments.

Tracing conceptual knowledge. This learning process refers to the acquisition of the knowledge of "when and why." For example, the student knows the value of knowing different types of reading strategies. The learning objective, conditional information, implies the ability to perceive the criteria, values, and/or appropriateness for employing concepts, rules and principles. The KB represents an analysis of the schematic network associations and the rules which governor the connections. Knowledge in a KB is represented in a variety of ways. For purposes of education, it is often possible to represent this information in a number forms: for example, a taxonomy, a category, or a hierarchy. The KB here is structured to represent how the knowledge may be organized in memory. Of importance to the KB is the identification of criteria associated with the structure. For example, the learning objective suggests that the student needs to know the conditions of employment as well as the how of employment.

The instructional variables for this learning process influence student learning in two ways: First, they provide an opportunity for the students to experience the KB; and second, they allow the students an opportunity to develop criteria, values, and appropriateness. Very often these variables are used in all of the identified instructional strategies. The variables of context and advance organizer improve the initial awareness of what is to be learned by helping the student to select and organize appropriate existing knowledge. For example, selecting a specific method or strategy for organizing resources to study. Feedback and strategy information improve the integration of the new knowledge into the KB.

Cooperative learning group techniques improve conceptual knowledge acquisition by allowing students to both develop solutions and see alternative solutions to problem situations. Within heterogeneous groups, the students work towards a specific goal by using their respective abilities and aptitudes and, by doing so, improve their understanding of the criteria, values, and appropriateness of knowing when and why to employ knowledge. The task-oriented simulation allows students to work on situations that replicate the employment of the knowledge they are acquiring. Such employment requires them to make decisions on knowledge selection and organization and, by working in a group, see how their ideas relate to the others. Computer-based simulations can provide ease in adjusting the variables and conditions of situations as well as delivering the simulation.

Tracing retrieval skills. Most often cognitive theories of learning focus on knowledge acquisition while basically ignoring employment of knowledge in the service of thinking (i.e., recall, problem solving, and creativity). However, the main goal of education is not acquisition of knowledge, but the improved skill in using it. The traditional schooling paradigm of learning information to develop a disciplined work ethnic only indirectly helped students improve their skills in thinking. Contemporary cognitive psychology that deals with retrieval system theory indicates that thinking skills develop most adequately when working concurrently with the KB. That is, thinking skills in recall, problem solving, and creativity are developed not as general strategies but as specific forms of knowledge embedded in the schemata. And, as skills, the thinking processes of differentiation, integration and creation can be developed and improved. Therefore, such skill development should be an integral part of the instructional system.

For example, my general recommendations for learning time allocation in a curriculum plan for each learning process is as follows: declarative knowledge, 10%; procedural knowledge, 20%; conceptual knowledge, 30%; and thinking skill, 40%. That is, rather than using almost 100% of the instructional time for the learning objectives of knowledge acquisition, a major part of the time needs to be allocated to thinking skill development and improvement. The shift from the traditional schooling paradigm of focus on knowledge acquisition to increased emphasis on thinking skill development puts learning responsibility, or power, more in the hands of the student. This is accomplished by instructional strategies that employ problem-oriented simulations within cooperative learning group techniques.

Problem-oriented simulations (Tennyson, Thurlow, & Breuer, in press) present meaningful and complex problem situations in which students are required to make solution proposals using knowledge stored in memory. The basic format of the simulation is to group students according to similarity of cognitive complexity (i.e., their general skills in differentiation and integration). Within the group, each student is to prepare a proposal individually and then present it to the group. At this point, the student is to advocate his/her proposal. Because of the conflict in this format, each student sees increasingly sophisticated alternatives to the situation which helps them both develop thinking skills and to elaborate and extend their schemata. Additionally, as the simulated variables and conditions change, the students are faced with situations that require them to create knowledge to make proposals. The computer-based enhancements include both the conventional methods of simulation variables and conditions adjustments as well as intelligent methods of monitoring the progress and needs of each student.

Summary

In this article I have presented a means by which educators can determine if specific media variables and methods may improve learning. Thus, I did not attempt to debate whether or not media improves learning. Media is but one component in a complex instructional system. A system that involves principles of instructional design as well as methods of instructional delivery. What I have shown here is that to assume that given instructional methods improve learning, those methods must have two aspects. First, they must exhibit a direct trace to a specific learning process. And, second, they must have empirical support that demonstrates their significance.

Because of the focus of this symposium on the programmatic research of the presenters, I have basically limited my example of the tracing process to my research findings. That of course limits the generalization of the answer to the question on the effect of media on learning, but I am sure others who have done basic research in instructional technology could make a similar effort. By doing so, there would be additional support for understanding the role of media in improving learning.

Bibliography

Blount, H.P., & Tennyson, R.D. (1972). Programmed instruction as a model for instructional design. NSPI Newsletter, 11 (8), 5-9.

Johansen, K.J., & Tennyson, R.D. (1984) Effect of adaptive advisement on perception in learner controlled, computer-based instruction using a rule-learning task. Educational Communication and Technology Journal, 31, 226-236.

L'Allier, J.J., & Tennyson, R.D. (1980). Principles of instructional design applied to an introductory course on educational computing. Journal of Computer-based Instruction, 7, 26-32.

Park, O., & Tennyson, R.D. (1980). Adaptive design strategies for selecting number and presentation order of examples in coordinate concept acquisition. Journal of Educational Psychology, 72, 362-370.

Park, O., & Tennyson, R.D. (1984). Computer-based instructional systems for adaptive education: A review. Review of Contemporary Education, 2, 121-135.

Park, O., & Tennyson, R.D. Response-sensitive design strategies for sequence order or concepts and presentation form of examples using computer-based instruction. Journal of Educational Psychology, 78. 153-158.

Rothen, W., & Tennyson, R.D. (1978). Application of Bayes' theory in designing computer-based adaptive instructional strategies. Educational Psychologist, 12, 317-323.

Tennyson, H.H., & Tennyson, R.D. (1982). Applications of microcomputers in clinical psychology. International Review of Applied Psychology, 31, 523-537.

Tennyson, R.D. (1972). A review of experimental methodology in instructional task sequencing. AV Communications Review, 20, 147-159.

Tennyson, R.D. (1974). Applications of computers in education. Audio-Visual Instruction, 19 (5), 49-52.

Tennyson, R.D. (1975). Adaptive instructional models for concept acquisition. Educational Technology, 15 (9), 7-15.

Tennyson, R.D. (1980). Instructional control strategies and content structure as design variables in concept acquisition using computer-based instruction. Journal of Educational Psychology, 72, 525-532.

Tennyson, R.D. (1981). Use of adaptive information for advisement in learning concepts and rules using computer-assisted instruction. American Educational Research Journal, 18, 425-438.

Tennyson, R.D. (1981). Interactive effect of cognitive learning theory with computer attributes in the design of computer-assisted instruction. Journal of Educational Technology Systems, 10 (2), 175-186.

Tennyson, R.D. (1984). Artificial intelligence methods in computer-based instructional design: The Minnesota adaptive instructional system. Journal of Instructional Development, 7 (3), 17-22.

Tennyson, R.D., & Boutwell, R.C. (1974). An audio-tutorial instructional approach to individualized college geology. Improving Human Performance, 3, 15-21.

Tennyson, R.D., & Breuer, K. (1984). Cognitive-based design guidelines for using video and computer technology in course development. In O. Zuber-Skerritt (Ed.), Video in higher education (pp. 26-63). London: Kogan.

Tennyson, R.D., & Buttrey, T. (1984). Advisement and management strategies as design variables in computer-assisted instruction. In D.F. Walker & R.D. Hess (Eds.), Instructional software (pp. 158-165). Belmont, CA: Wadsworth.

Tennyson, R.D., & Christensen, D.C. (in press). MAIS: An intelligent learning system. In D.H. Jonassen (Ed.), Instructional designs for microcomputer courseware. Hillsdale, NJ: Erlbaum.

Tennyson, R.D., Christensen, D.L., & Park, S.I. (1984). The Minnesota adaptive instructional system: An intelligent CBI system. Journal of Computer-based Instruction, 11, 2-13.

Tennyson, R.D., & Park, O. (1984). Computer-based adaptive instructional systems: A review of empirically-based models. Machine-Mediated Learning, 1, 129-153.

Tennyson, R.D., & Park, O. (1987). Artificial intelligence and computer-assisted learning. In R. Gagne (Ed.), Instructional technology: Foundations. Hillsdale, NJ: Erlbaum.

Tennyson, R.D., Park, O., & Christensen, D.L. (1985). Adaptive control of learning time and content sequence in concept-learning using computer-based instruction. Journal of Educational Psychology, 77, 481-491.

Tennyson, R.D., & Park, S.I. (1984). Process learning time as an adaptive design variable in concept learning using computer-based instruction. Journal of Educational Psychology, 76, 452-465.

Tennyson, R.D., & Park, S.I. (1985). Interactive effect of process learning time and ability level on concept learning using computer-based instruction. Journal of Structural Learning, 8, 241-260.

Tennyson, R.D., & Rothen, W. (1977). Pretask and on-task adaptive design strategies for selecting number of instances in concept acquisition. Journal of Educational Psychology, 69, 586-592.

Tennyson, R.D., & Rothen, W. (1979). Management of computer-based instruction: Design of an adaptive control strategy. Journal of Computer-based Instruction, 5, 63-71.

Tennyson, R.D., Thurlow, R., & Breuer, K. (in press). Problem-oriented simulations for the improvement of higher-level thinking skills. Computers in Human Behavior.

Tennyson, R.D., Welsh, J.C., Christensen, D.L., Hajovy, H. (1985). Interactive effect of content structure, sequence, and process learning time on rule learning using computer-based instruction. Educational Communication and Technology Journal, 33, 40-71.

Are Media Merely Vehicles for Instruction?

Bill Winn

University of Washington.

January, 1987.

412 Miller Hall DQ-12.
University of Washington,
Seattle, WA 98195.

Media Research

Clark's (1983) statement that media have no real effect on learning has raised a number of issues that have proven to be quite controversial amongst both the scholars and the practitioners within the Educational Technology field. The purpose of this short paper is to assess the validity of Clark's claim from a number of perspectives. In so doing, it seeks to remind readers of the context in which Clark's comments were made and of the fact that his criticism was aimed at one particular aspect of media, namely their delivery role, and not at others, such as their efficiency.

People need to remember that Clark's paper is first and foremost a criticism of media research. There are two related premises that underlie his criticism. The first is that confounding leaves open a variety of interpretations of the results of studies that purport to demonstrate the instructional superiority of media. The second is that once the sources of confounding are removed from experiments, all that is left to vary is the way in which the media deliver their messages. Clark claims that how instructional messages are delivered has absolutely no effect on learning -- his "mere vehicles" statement. If Clark had only made the first criticism, then he would not have been able to conclude that media do not make a difference in instruction, only that the studies addressing the issue have been poorly designed and interpreted. The argument that media do not make a difference arises from his second criticism, namely that all they do is deliver information. It is with this that most of this paper will be concerned.

Before moving on, however, it is necessary, for reasons that will become apparent at the conclusion of the paper, to mention the purpose of the type of research that Clark criticizes. A number of scholars have stressed that what the field needs is a good theoretical foundation which at present it does not have. For example, Stewart (1985) complains that Educational Technology is concerned with techniques (tricks of the trade) at the expense of theoretical principles that can guide practice more generally. Salomon (1979) has called these "explanatory principles" of how and why things work the way they do, as opposed to prescriptions which, as he points out, practitioners rarely use anyway. The orientation that research in our field should take is therefore towards the construction of valid and robust explanatory theories that provide a framework within which to generate hypotheses and develop instructional theory. The power of explanatory theory, as opposed to mere descriptions and certainly to techniques, lies in its affirmation of cause-and-effect relationships rather than just correlations among constructs. It is therefore created by testing truly experimental rather than correlational hypotheses. We shall return to this later.

Five Aspects of Media

Salomon (1979) precedes his well-known discussion of symbol systems by identifying four aspects of media that might, potentially at least, affect how people learn from them. These are: the technology they use, the symbol systems they employ, the content they convey, and the setting in which one encounters them. To these, it is useful to add a fifth: the thoroughness that goes into the design of the messages that they convey. This is a principle source of confounding identified by Clark, particularly in studies of the effectiveness of CAI (Clark, 1985a, 1985b).

Clark's criticism is aimed at those who test hypotheses concerning the relative impact on learning of the first of these five aspects of media, namely the technology they employ. The technology is simply responsible for the delivery of instruction to students. The technology is the "delivery van" of Clark's metaphor. His criticism does not extend to research into the other four aspects of media. Clark implies that it isonly the technology that can be uniquely associated with each medium. The other aspects cut across several media.

This leaves us with some unanswered questions. The first is: Do the other aspects of media -- their symbol systems, the content they convey, the setting in which they are placed and the care with which they are designed -- affect learning? The second is: If any of these four is related to learning, then are a medium's symbol system, content, setting and design in any way dependent upon their delivery technology? If the answer to this last question is "yes", then, apparently, there is a relationship between delivery technology and learning, albeit an indirect one.

Evidence for Impact on Learning

Beginning with the first of these two questions, the answer with respect to all four aspects of media is "yes". Salomon has demonstrated empiricially (1974; see also Bovy, 1983) and argues on theoretical grounds that symbol systems certainly affect how a person learns. Indeed, his research on Sesame Street when it was introduced into Israel goes so far to propose that a symbol system can mould the mental skills of young children. In my own work (Winn, 1986; Cochran et al., 1986) it has been found that varying the repleteness of the symbols representing elements in maps and diagrams affects the way in which students perform tasks requiring serial or parallel processing of the information.

That variations in content affect what people learn is self evident. If a medium carries information about a football game people will learn something different than if it had conveyed information about raising goats.

The setting in which people interact with media also has an effect on how they learn from them. This is true for both the social setting and, in a narrower sense, for cognitive "setting". The former is illustrated by Salomon's (1977) finding that encouraging mothers to watch Sesame Street with their children resulted in improved posttest scores for some children. In general, one finds that media viewed in the home tend to be considered as entertainment, while media viewed in school or in the workplace tend to be considered instructional.

In the narrower sense, Salomon (1984) has observed that what might be referred to as a "cognitive setting" also affects what people learn from media. For example, television is thought to be easier to learn from than print with the result that students will invest less mental effort in learning from it. The result is that students often learn less from media that they consider "easy". A similar finding has been reported by Clark (1980) for instructional methods that students prefer. However, as in the case of the co-observing mothers, these effects on learning are indirect. That is to say, for children from a low SES background, watching Sesame Street with their mothers increased first the enjoyment of the program which in turn improved their posttest scores. Believing that television is easier means that students will not try as hard to learn from it as, say, from text. This in turn means that they will learn less.

Like the impact of content on what people learn from media, that the carefulness with which the instruction they carry is designed has an impact on what students learn is obvious. Evidence for this is abundant, and Clark (1985a) cites much of it in his meta-analysis of CAI research. Yet one hardly needs evidence from studies to convince one that instruction designed and especially field-tested to meet minimal instructional criteria, as just about every design model requires (Dick and Carey, 1985; Gagne and Briggs, 1979; Romiszowski, 1981, and many others), should be more successful than instruction that is not. One could even argue that superior effectiveness is de facto a characteristic of instruction that has been field-tested to a given criterion. (That does not mean that its other apsects, such as its flexibility, are superior. But that is another story). However, such a claim is still in need of empirical verification (Gerlach, 1984).

There is evidence, then, that although delivery technologies may not have an impact on what and how students learn from media, the symbol systems a medium employs, its content, the setting in which it is encountered, and the thoroughness with which the instruction it carries is designed all influence learning. There are two ways in which this evidence is typically interpreted. The first is to affirm, as the advocates of media do, that, because these are all aspects of media, media therefore influence learning. The second interpretation is to argue that none of these four factors is uniquely associated with a single medium, and that therefore they should be considered as sources of confounding and controlled for in media studies. The way to resolve this apparent contradiction is to look for evidence of relationships between technologies and the other four aspect of media. If such relationships can be found, then the case of the media advocates is apparently strengthened.

Evidence for Relationships between Technology and Other Aspects of Media

Are delivery technologies in any way associated with symbol systems? Indeed they are. In fact, Salomon (1979) defines a medium in terms of its technology and its symbol system. He points out that a technology is a necessary (but not sufficient) condition for the emergence of a new symbol system. Photography could not exist without the camera, nor is it likely that a great many of the special graphic effects we see every day on television would have developed without the optical, electronic and digital technologies that create them. Although a medium begins by borrowing the symbol systems of other media, as television did from film and radio, and computers did from workbooks, which means they are by no means unique, the characteristics of the technology eventually permit the emergence of new symbol systems that are uniquely associated with that technology.

Content types are also associated with particular media. Newspapers carry information and opinions about current events, while books do not. Television carries commercials while film does not. Slides carry information about the way things look while printed texts tend to be more discursive. This is not to say that a particular medium is not capable of carrying all types of content. Rather it is the custom that it does not. The reasons are cultural and historical, not technical and psychological.

The same cultural and historical explanation is appropriate for the associations between technology and setting. The technology of film allows images of extremely high quality to be enlarged to the point where they can be viewed by hundreds of people at once. The relatively poor quality of enlarged television images precludes their viewing in such large groups effectively restricting television viewing to the home or classroom. Similarly, books are typically read silently by one person at a time. It is neither as effective nor as efficient to read them out loud to large groups. This does not mean that television cannot be shown in movie theaters nor that books cannot be read to large groups. It simply does not usually happen that way.

The technological aspect of media likewise is accociated with how well the instruction they deliver is designed. The technology embodied in a computer permits a student to study alone, interactively, without the assistance of a teacher. However, to be successful such instruction must be meticulously planned and programmed. The designer must anticipate everything that is likely to occur once instruction has started that will affect how a student learns. When a teacher is involved, this is not the case. Instructional problems can be dealt with as they arise, which requires less thorough planning. The same is true of any mediated presentation that is intended to stand alone. Even mediated resources that are intended for use by a teacher require that pre- and post-presentation activities be planned. Again, this is not to say that CAI must be better planned than teacher-based instruction or that slide sets must be accompanied by prescribed activities. It is just the way it is usually done when it is done well.

Previously we established that a medium's symbol system, content, setting and design affect learning. We have now argued that symbol systems, content, setting and design are typically associated with a medium's technology. It seems logical to conclude that delivery technology must therefore affect learning as media advocates have claimed all along. But does this really follow? In the context of media research, which we must remember is what

Clark's paper was all about, it does not as we shall now see.

A Flawed Conclusion

The crucial step in the argument that media affect learning is the last one we examined -- the link between symbol systems, contents, setting and design with delivery technologies. The flaw in the conclusion that is typically drawn after presenting the sort of argument we did lies in the fact that symbol systems, contents, setting and design are correlates of a medium's technologies, nothing more. Thus, as we saw, television may use symbol systems that are as much aspects of other media as they are of it, and may not use the symbol systems it has helped to evolve. This is the case whenever a film is shown on television, whenever television shows a still picture or graphic, or whenever it shows a picture of a "talking head". A considerable percentage of the broadcast time of television is devoted precisely to these types of message. (It is perhaps ironic that it is in commercials that the greatest proportion of the unique symbol systems of television occur). We also saw that the contents of media and the settings in which they are usually encountered are more a result of custom than they are of anything else. In theory, any medium can convey any contents and can be used in any setting. Thus, films can carry news stories (remember the Pathe newsreels?), films can be shown in the living room, as home movies usually are, computers can show "slides", newspapers can serialize novels, and so on. Also, we saw that the messages delivered by technologies that permit students to study alone do not have to be better planned than those delivered by teachers. They just usually are. These examples may not account for the majority of times that a medium is used, but they are certainly the case a significant number of times.

The implication of this, of course, is that the relationships between delivery technologies and symbol systems, setting and design are correlational rather than causal, descriptive rather than explanatory. Researchers have observed that these relationships exist, but have not established any causality within them. By implication, the same applies to the relationship that might exist between delivery technology and learning. Because a researcher observes that students studying from a computer perform better than students studying from a workbook does not mean that the computer causes them to learn better. Moreover, the researcher's observation does not even explain why this appears to be the case. It simply records that it happened.

Research and Practice

We have in a sense come full circle. We began with the idea that the role of research in our area should be first to develop explanatory theory. Any discipline that thinks it can survive on rules of thumb is doomed to fail, and we have come pretty close to failure, for this reason, in Educational Technology. In our field, we like to insist that we bridge the gap between research and its application, between theory and practice, better than most educators. However, we have failed to acccomplish this. The reason is that our research agendas have sought the short-term payoff at the expense of long-term theory-building. It has been more profitable, in terms of our apparent prestige and even our pocketbooks, to find solutions to instructional problems that work for the moment. This "quick fix", "instant remedy" attitude pervades every aspect of our culture from cold remedies to social programs to foreign policy. But it is a dangerous attitude indeed in a science. So while it might be convenient, for the moment, to kid ourselves that media make a difference, and that we know how to select the right medium for the given objective, we must face up to the fact that we usually cannot explain why it is we make the recommendations we do. Fortunately few people have asked us to.

However, we have been caught out on many occasions. For example, we touted instructional television for a number of years. It worked, up to a point. But when it failed to live up to its expectations, we could only explain why in terms that avoided the real issues -- teachers refused to use it; it cost too much; people did not put enough money into producing quality programs. These read like excuses rather than explanations. If we had really understood that it was not television per se that was involved in any apparent improvements, but other "confounding" factors, we would have directed our attention not at the medium of television but at the instructional methods that users of television might employ with students, the settings in which instruction takes place, the cognitive processes it engages through its use of symbols, and so on.

A more current example concerns computers. Researchers have observed that CAI appears to improve student performance under a number of circumstances. As Clark (1985) has pointed out, the reasons we have given for this phenomenon have been faulty. But, we tell ourselves, it does not matter that the reason for the apparent superiority of CAI is, for instance, a Hawthorne effect and nothing intrinsic to the computer. Indeed, there is nothing wrong with designers exploiting the Hawthorne effect if it leads to better performance. However, what happens when computers are no longer a novelty, they no longer appear to provide superior instruction, and we cannot explain why? Our reputation suffers another setback and computers lose favor, just as instructional television did, for the wrong reasons.

Conclusion

At the root of many of the great tragedies in our literary tradition, from Sophocles to Ibsen, lies the lack of awareness of the tragic hero of what is going on around him. In that tradition things that one could not explain were attributed to Fate or to God. We, however, profess a different tradition, a "scientific" one that is based upon knowledge. The root of that tradition is understanding of what occurs so that we can explain it to ourselves and to others. Yet, in spite of our avowed rationalism, we cannot but fail to note a fatalism in the way in which we conduct research and develop instruction. We promote a promising medium, design poor experiments to study it whose results, like the pronouncements of the Delphic oracle, can be interpreted in a number of ways, one of which always supports our faith in the medium. We continue to this, without really being able to explain why we are getting the results we observe, until the medium begins to fail us. We then dump it having learned nothing, and begin the whole process over again with another medium.

This is indeed tragic. If we were to develop explanatory theories operating at the level of principles rather than developing techniques whose validity is limited, we would be far more successful. In this regard, Clark is absolutely right. The media have nothing to with accounting for how people learn. Higher-order principles, or "methods", do, and it is these that we need to discover, promulgate and understand.

References

Bovy, R. (1983). Defining the psychologically active features of instructional treatments designed to facilitate cue attendance. Presented at the meeting of the American Educational Research Association, Montreal, April.

Clark, R.E. (1983). Reconsidering research on learning from media. Review of Educational Research, 53, 445-460.

Clark, R.E. (1985a). Confounding in educational computing research. Journal of Educational Computing Research, 1, 137-148.

Clark, R.E. (1980, April). Do students enjoy the instructional method from which they learn the least? Antagonism between enjoyment and achievement in ATI studies. Annual meeting of AERA, Boston.

Clark, R.E. (1985b). Evidence for confounding in computer-based instruction studies: Analyzing the meta-analyses. Educational Communication and Technology Journal, 33, 249-262.

Cochran, V., Conroy, P., Ouellette, M., Sutherland, S., Wiess, U., and Winn, W. (1986). The effect of the number and nature of features and of general ability on the simultaneous and successive processing of maps. University of Washington, unpublished paper.

Dick, W., and Carey, L. (1985). The Systematic Design of Instruction. Glenview, IL.: Scott Foresman, second edition.

Gagne, R.M., and Briggs, L.J. (1979). Principles of Instructional Design. New York: Holt, Rinehart and Winston, second edition.

Gerlach, V. (1984). Trends in instructional technology research. In J.W. Brown and S.N. Brown (Eds.), Educational Media Yearbook 1984. Littleton, CO.: Libraries Unlimited Inc., 24-33.

Romiszowski, A.J. (1981). Designing Instructional Systems. New York: Nichols Publishing Company.

Salomon, G. (1977). Effects of encouraging Israeli mothers to co-observe "Sesame Street" with their five-year-olds. Child Development, 48, 1146-1151.

Salomon, G. (1979). Interaction of Media, Cognition and Learning. San Francisco: Jossey Bass.

Salomon, G. (1974)> Internalization of filmic schematic operations in interaction with learners' aptitudes. Journal of Educational Psychology, 66, 499-511.

Salomon, G. (1984). Television is "easy" and print is "hard": The differential investment of mental effort in learning as a function of perceptions and attributions. Journal of Educational Psychology, 76, 647-658.

Stewart, A. (1985). Appropriate educational technology: Does "appropriateness" have implications for the theoretical framework of educational technology? Educational Communication and Technology Journal, 33, 58-65.

Winn, W.D. (1986). Simultaneous and successive processing of circuit diagrams having different amount of detail. Paper presented at the meeting of the American Educational Research Association, San Francisco: April.

Prose-Relevant Pictures and Recall From Science Text

Gary J. Anglin and J. Truman Stevens

College of Education

University of Kentucky

Running head: PICTURES AND RECALL FROM SCIENCE TEXT

Summary.-- The effects of prose-relevant pictures on 42 college students' prose recall were studied. Students were given one of two instructional treatments (prose-plus-pictures, prose-only) which included science content. An immediate- and delayed-recall criterion measure was administered. The prose-plus-picture group's mean criterion test score was significantly greater than that of the prose-only group in the immediate testing condition.

During recent years, many junior and senior high school, and college textbooks have presented large numbers of illustrations and pictures with the written text materials (Individualized Science Instructional System, 1980; Intermediate Science Curriculum Study [ISCS], 1973; Intermediate Science Curriculum Study, 1973, 1970; Wong, Bernstein, & Shevick, 1978). In some cases, as much page space is devoted to pictures as is to the written text.

Many science curriculum materials stress active investigative behavior on the part of students, problem-oriented activities, individualization of instruction, and the development of the inquiry processes of science (Intermediate Science Curriculum Study, 1972). While one may agree that process-oriented goals should be major outcomes of science instruction, it is still desirable and necessary for students to remember information. Gagne and Briggs (1974) suggested that:

> Students of science learn much verbal information, just as they do in other fields of study. They learn the properties of materials, objects, living things, for example. A large number of "science facts" may not constitute a defensible primary goal of science instruction. Nevertheless, the learning of such "facts" is an essential part of the learning of science. Without information, learning in any subject could have no continuity, no "substance" (p. 53).

It can be argued that one must recall observations or information to develop concepts and ideas of science. In addition, it may be necessary to understand factors influencing the recall of information prior to developing a full understanding of factors influencing the development of higher level cognitive outcomes.

Early investigations on the use of pictures as adjuncts to written prose materials by Vernon (1953) and Burdick (1960) using instructional treatments including science content, supported the conclusion by Samuels (1970) that "there was almost unanimous agreement that pictures, when used as adjuncts to the printed text, do not facilitate comprehension" (p. 405). In a review of pictorial research related to science education, Holliday (1973) concluded that:

> pictures in conjunction with related verbal material can facilitate recall of a combination of verbal and pictorial information. It is suspected that pictures can increase comprehension in some cases; however more empirical evidence is needed (p. 210).

There is now substantial support for the claim that prose-relevant pictures do contribute to increased recall of prose materials, particularly if the subjects are young children. (Holliday, 1975; Holliday & Harvey 1976; Holliday & Thursby, 1977; Levie & Lentz, 1982; Levin, 1981; Levin, Anglin & Carney, in press; Levin & Lesgold, 1978; Willows, Borwick, & Hayvren, 1981). Levie and Lentz (1982) conclude that "illustrations facilitate learning the information in written text that is depicted in illustration" (p. 231). Levie and Lentz found that the average improvement for groups reading with pictures was 36%. Holliday's (1973) call for more empirical studies remains valid, particularly if studies include instructional treatments from existing science textbooks and subjects are science students.

The purpose of this study was to investigate the contribution of prose-relevant pictures to immediate- and delayed-recall of written prose which included science content, when the audience included older learners (college undergraduates).

Method

Subjects

Subjects were 42 students enrolled in one of two sections of an undergraduate graduate science teaching methods course for elementary education majors. Most of the subjects were juniors and seniors and a majority were female. The students had limited backgrounds in the sciences. The content presented in the treatment has not been previously discussed in the methods course. Students participating in the study had previously passed basic competency examinations in reading, writing, and mathematics. To pass these examinations, a student was required to score at or above the level of the average high school senior on each of the tests.

Materials

Instructional treatments were adapted from "Speed in Less Than 1 Second" (ISCS, 1970). The prose passage discussed how to make and use a water clock to measure small time intervals. The passage also described how to use the water clock to study velocity and acceleration. The primary alteration of the material consisted of eliminating the laboratory component of the activity and removing the pictures for the prose-only treatment. While the investigators are interested in the active involvement of the learner in science classes, this study examined the possible contribution of pictures to the recall of information in written prose materials. The prose-passage informed students how to do the tasks but did not require them to perform the investigation. A sample of the written prose follows:

> First, let's get a "feel" for how the water clock works. Water is poured into the funnel-shaped clock. If the clock is held vertically, drops of water come out of the clock. When a wet square of paper is placed on top of the water clock, the paper keeps the water from dripping.

The pictures that accompanied the sample prose passage are displayed in Fig. 1. Slight modifications in the ISCS (1970) text and pictures were made to add clarity.

Insert Figure 1 about here.

Subjects in the experimental group had 12 pages of reading material, including one paragraph on each page. The paragraph was located on the left side of the page. The right side of each page contained one to three prose-relevant pictures. All pictures were line drawings and represented the narrative being presented. Students in the control group read the exact same written prose passage without pictures.

A 12-item multiple choice test was developed to test for recall of information presented in the prose passage and represented in the pictures. Significant picture effects have been found with various test formats (Levie & Lentz, 1982). A sample item from the criterion measure follows:

> Which of the following happens when you pour water into an uncovered water clock?
>
> A. the water drops fall at regular intervals
> B. a stream of water flows through the clock
> C. the water pushes the cart along a plane
> D. the water is held in the clock
> E. the water rusts the water clock

Design and Procedure

Students were randomly assigned one of two instructional treatments (prose-plus-pictures, prose-only). There were 22 subjects in the prose-plus-picture and 20 in the prose-only condition. They were asked to take designated seats in one of two areas in the classroom. The same information was presented on each student's cover sheet and instructions were given orally to the students. Students were instructed to read the selected material and review the accompanying pictures (prose-plus-picture group) one time and to raise their hands upon completion of the reading. All students completed the treatment within a 15-min time period.

A 12-item multiple-choice test was immediately administered to all subjects. Twenty-eight days later the same subjects were retested using the same criterion-test. The delayed test was unannounced and administered using the same instructions used for the immediate test. The subjects did not re-read the prose passages prior to the delayed test.

Results

The experimental group (prose-plus-pictures) average criterion test score (82%) was significantly greater than that of the control subjects (70%) in the immediate condition ($t_{40} = 2.08$, $p < .05$). The criterion measure discrimination index was 0.41. The Kuder-Richardson Index was 0.67 and the standard error of measurement was 1.37.

Insert Table 1 about here.

After a 4-wk. delay, the experimental group's average criterion test score (62%) did not differ significantly from that of control subjects (57%), t <100. Both groups (prose-plus-pictures, prose-only) scored significantly lower on the delayed test than on the immediate test. The prose-plus-picture groups average recall was significantly lower in the delayed testing condition, (paired $\underline{t}_{21} = 7.50$, $p < .001$). Prose-only subjects also recalled significantly less in the delayed testing condition, (paired $\underline{t}_{20} = 3.59$, $p < .01$).

Discussion

The inclusion of representational pictures with written prose materials resulted in significantly higher average recall for the prose-plus-picture group in the immediate testing condition. The magnitude of the picture effects in the immediate testing condition are similar to those identified in previous studies using other types of prose passages, i.e., fictional narratives and human interest stories (Anglin, in press; Levin & Berry, 1980; Peng & Levin, 1979). Subjects' average recall in the prose-plus-picture condition was 12% higher than for the prose-only group. Levin (1981) has argued that representational pictures produce a stronger memory trace than the trace associated with a verbal representation of the text.

The picture effects were not durable over time (28 days). This finding is not consistent with results from previous studies using other types of prose passages (Anglin, in press; Levie & Lentz, 1982; Levin & Berry, 1980; Peng & Levin, 1979). The lack of picture effects in the delayed testing condition may be due to: (a) passage type and/or (b) the type of test items used in the multiple choice criterion instrument.

The durability of picture effects may vary across passage types. Fictional narratives or human interest stories may be more memorable than the type of prose passage used in the current study. The type of criterion-test items used may also have contributed to the lack of picture effects in the delayed testing condition.

Anderson (1972) recommends the use of paraphrased questions to infer comprehension. Replicating this study using paraphrased questions would be informative. However, as previously discussed in this paper, significant picture effects have been found with various test formats. Further study examining the effect of type of passage and the test questions used in the criterion measure are worth pursuing.

References

Anderson, R. C. (1972) How to construct achivement tests to assess comprehension. *Review of Educational Research*, 42, 145-170.

Anglin, G. J. (in press) Prose-relevant pictures and older learners' recall of written prose. *Educational Communication and Technology Journal*.

Burdick, J. G. (1960) A study of cross-section drawings used as technical illustrations in high school science textbooks (Doctoral dissertation, Syracuse University, 1959) *Dissertation Abstracts International*, 20, 2707-2708.

Gagne, R. M., & Briggs, L. J. (1974) *Principles of instructional design*. (2nd ed.) New York: Holt, Rinehart & Winston.

Holliday, W. G. (1973) Critical analysis of pictorial research related to science education. *Science Education*, 57, 201-214.

Holliday, W. G. (1975) The effects of verbal and adjunct pictorial-verbal information in science instruction. *Journal of Research in Science Teaching*, 12, 77-83.

Holliday, W. G., & Harvey, D. A. (1976) Adjunct labeled drawings in teaching physics to junior high school students. *Journal of Research in Science Teaching*, 13, 37-43.

Holliday, W. G., & Thursby, P. M. (1977, April). *Teaching visual concepts in the classroom*. Paper presented at the meeting of the Association for Educational Communications and Technology, Miami.

Individualized Science Instructional System. (1980) *Kitchen chemistry: annotated teachers edition*. Lexington, MA: Ginn.

Intermediate Science Curriculum Study. (1970) *Probing the natural world*. Vol. 1. Morristown, NJ: Silver Burdett.

Intermediate Science Curriculum Study. (1972) *Individualized teacher preparation: rationale for individualization*. Morristown, NJ: Silver Burdett.

Intermediate Science Curriculum Study. (1973) Individualized teacher preparation: human variability. Morristown, NJ: Silver Burdett.

Levie, W. H., & Lentz, R. (1982) Effects of text illustrations: a review of research. Educational Communication and Technology Journal, 30, 195-232.

Levin, J. R. (1981) On functions of pictures in prose. In F. J. Pirozzolo & M. C Wittrock (Eds.), Neuropsychological and cognitive processes in reading. New York: Academic Press.

Levin, J. R., Anglin, G. J., & Carney, R. N. (in press). On empirically validating functions of pictures in prose. In D. M. Willows & H. A. Houghton (Eds.), Illustrations, graphs and diagrams: Psychological theory and educational practice. New York: Springer-Verlag.

Levin, J. R., & Berry, J. K. (1980) Children's learning of all the news that's fit to picture. Educational Communication and Technology Journal, 28, 177-185.

Levin, J. R., & Lesgold, A. M. (1978) On pictures in prose. Educational Communication and Technology Journal, 26, 233-243.

Peng, C. Y., & Levin, J. R. (1979) Pictures and children's story recall: some questions of durability. Educational Communication and Technology Journal, 27, 39-44.

Samuels, S. J. (1970) Effects of pictures on learning to read, comprehension, and attitudes. Review of Educational Research, 40, 397-407.

Vernon, M. D. (1953) The value of pictorial illustration. British Journal of Educational Psychology, 23, 180-187.

Willows, D. M., Borwick, D., & Hayvren, M. (1981) In T. G. Waller & G. E. MacKinnon (Eds.), Reading research: advances in theory and practice (Vol. 2) New York: Academic Press.

Wong, H. K., Bernstein, L., & Shevick (1978) Life science. (2nd ed.) Englewood Cliffs, NJ: Prentice-Hall.

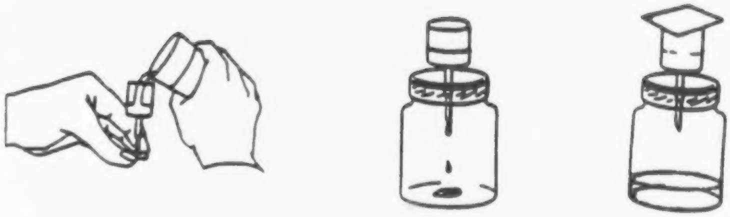


Fig. 1. Pictures accompanying sample prose passage in experimental condition

Table 1

Comparison of Experimental and Control Groups on Immediate and Delayed Tests

	Group					
	Experimental (n=22)		Control (n=20)			
Test	Mean	S.D.	Mean	S.D.	Independent t-value	Prob.
Immediate	9.86	1.98	8.40	2.56	2.08*	0.044
Delayed	7.40	2.20	6.85	2.41	0.79	0.436

*$p < 0.05$

Introverted Approaches to Instructional Media Research: Eliciting Perceptual Processes Which Contribute to Learning

Ronald J. Aust
University of Kansas

Instructional Technology Center
Bailey Annex
University of Kansas
Lawrence, Kansas 66045
(913) 864-3057

Introverted Approaches to Instructional Media Research: Eliciting Perceptual Processes Which Contribute to Learning

Ronald J. Aust
University of Kansas

Instructional media researchers have often adopted theories of perception as conceptual guides for conducting research. Norberg (1953, 1962, 1966, 1978) identified two categories of perception theories and contended that each had distinct implications for instructional media research. One category is described as extroverted because it includes theories which are primarily concerned with characteristics of external stimuli and the influence that the corresponding sensory information has on the formation of mental representations or percepts. Extroverted theories assert that the meanings individuals draw from sensory information are primarily determined by the quality of the stimuli; inferring that the perceiver is relatively passive in perception. The other category of perception theories is described as introverted. Supporters of introverted theories believe that the most compelling aspects of perception are the self-directed internal processes that individuals use in constructing percepts from sensory information.

Assumptions underlying extroverted and introverted theories of perception have alternate implications for instructional media research. By emphasizing the importance of stimulus quality, extroverted theories imply that instructional media research should center on characteristics of mediated stimuli. These stimulus based approaches include: methods for making distinctions between "real world" and mediated stimuli, schemes for classifying differences in mediated stimuli and strategies for determining the amount and quality of stimuli which will optimize the understanding of specific concepts. Introverted theories presume that the individual is actively involved in the construction of percepts, implying that research should focus on media strategies for developing, enhancing, or eliciting internal perceptual processes which contribute to intelligence.

Much of the instructional media research and many of the media utilization models (Dale, 1969; Dwyer, 1970) and message design principles (see Fleming & Levie, 1978) have been based on extroverted theories of perception. However, despite Norberg's (1966, 1978) recommendations for pursuing research based on introverted theories, few such studies have been conducted. A comprehensive plan for conducting research based on introverted theories is needed. Moreover, this plan should lead to media strategies for establishing or eliciting perceptual processes which contribute to intelligence, as opposed to being concerned primarily with the acquisition of specific facts or concepts.

Perception: A Relevant Definition for Instructional Media Research

Before considering theories of perception in greater detail it is appropriate to define, or at least limit the meanings given to, the term perception. Debates regarding the nature of perception have crossed a wide range of disciplines including: art, education, engineering, philosophy and psychology. Lebowitz (1965) explained that this wide-spread interest has not yielded a universal definition, and suggested that interpretations be guided, to some extent, by the practical and theoretical needs of the users. The definition for perception, adopted by instructional media researchers, should: accord relevant means for identifying the primary mental processes under investigation, recognize possible contributions of affiliated processes, and provide a framework for determining how media can be used to promote the acquisition of mental processing skills.

Psychologists, Brown and Deffenbacher (1979) refered to physical world phenomena in terms of distal and proximal stimuli. Objects and events in the physical world are referred to as distal stimuli. Information about the distal stimuli which reaches the senses is called proximal stimuli, which may be in the form of light energy, sound waves, chemical molecules, heat, or pressure. In vision, the proximal stimuli emanating from an object takes the form of distinctive diffraction patterns of light energy. These distinctive diffraction patterns serve as an encoded representation of the object. When the encoded light energy strikes the viewer's eye, it cause a change in the firing rate of the receptor cells in retina. These initial sensory reactions to proximal stimuli are called sensation.

As sensory messages travel along the neural pathways to various locations in the brain, neural mechanisms alter the structure of the information prior to the formation of the percept (Cornsweet, 1970; Hubel & Wiesel, 1977). The mental development of the percept is further influenced by central mechanisms responsible for attending to and selecting certain aspects of the sensory information. These mechanisms also include constructive processes used in deriving meaning from sensory arrays (Gregory 1970; Gyr, 1972; Rock, 1983).

A complete description of perception includes both processes involved in sensation and central processes which may not require the direct input of sensory information.

As a long-standing precedence, psychologists (James, 1890; Wundt, 1970; Hillgard, Atkinson & Atkinson, 1971) have chosen to define perception in terms of conscious mental representations that have an immediate relationship to the proximal stimuli. Thus, perception is defined as, "The mental processes used in developing conscious percepts which are the immediate result of sensation." This definition makes a distinction between perceptual processes and higher-order cognitive processes used in the formation or manipulation of memorial representations. However, perception is also considered to be a subset of cognition; with perceptual processes having a reciprocal interaction with higher-order cognitive processes including hypothesis formation and problem solving (Neisser, 1966).

A definition for perception, that distinguishes between those mental processes which result in the formation of percepts and those which result in the formation of memorial representations, may serve as a guide for instructional media researchers. According to this definition a number of percepts might be formed while visiting the zoo, watching a film or reading a book. But the mental representations which remain once the individual has left the zoo, finished viewing Fantasia, or reading The Wizard of Oz, are formed by higher-order cognitive, as opposed to strictly perceptual processes. This is because the memorial representations are acted upon in absence of the corresponding sensory information. The memorial representation may be in the form of images which possess perceptual-like qualities (Shepard & Podgorny, 1978; Cooper & Shepard, 1970; Fleming, 1977), but the processes acting on their construction may also have some distinct differences which impact on learning (Richardson, 1969; Kosslyn & Pomerantz, 1977; Paivio, 1976). Thus, the distinction between percepts and images, and the corresponding processes used in their construction, might aid in the identification of media strategies for effecting the transfer of perceptual processes to higher-order cognitive processes affiliated with intelligence.

Research Based on Extroverted Theories of Perception

According to Gibson (1954, 1966, 1972), movement through the environment is the enabling factor in perception. Gibson claimed that as individuals moves through the environment they become aware of the invariant qualities of objects. The ability to differentiate objects is developed as perceivers begin to make associations between invariant qualities and the objects they represent.

Exposure to a wide variety of environmental stimuli has the more far-reaching effect of providing the learner with the basis for developing abilities to absorb invariant qualities more readily.

In his recommendations to media researchers, Gibson (1954) noted that media provide the means for exposing learners to an extensive variety of artificial or vicarious experiences which they may not otherwise have the opportunity to encounter. However, he stressed that the effectiveness of instruction with media is highly dependent on the nature of the media stimuli or surrogates employed. Gibson (1954) defined surrogate as "a stimulus produced by an individual which is relatively specific to some object, place or event not at present affecting the sense organ of the perceiving individual" (p.5).

Gibson identified two forms of surrogates; conventional and non-conventional. Conventional surrogates, such as words or numbers, are connected to their referents by conventions of arbitrary rules established by society. Non-conventional surrogates are replicative. In other words, the information projected by non-conventional surrogates is isomorphic to the information which would have been projected by its referent. Drawings, photographs and films are forms of non-conventional surrogates; although they vary in the degree to which the are replicative.

Extroverted theories which focus on the importance of invariant qualities and distinctive features (Travers, 1977) of stimuli have led to a number of schemata for classifying media attributes. The more recent schemata articulate distinctions which are similar to those made by Gibson in differentiating conventional and non-conventional surrogates. Kennedy (1974) and Levie (1978) referred to words and numbers as non-iconic symbols while drawings and photographs are described as iconic symbols. Other researchers (Olson & Bruner 1974; Salomon 1977), have recommended employing Goodman's (1968) notation scheme for determining relationships between media attributes and mental processes. While Goodman's scheme may provide greater differentiation between symbol systems, the essential distinction between verbal type and pictorial type systems is similar the distinction proposed by Gibson.

In Goodman's classification scheme, notational symbol systems, such as verbal language, numbers and music, are characterized by arbitrary conventions of syntax and semantics. More notational systems establish more precise connections between symbols and referents. Thus, highly notational symbol systems require the learner to develop precise associations between the symbol and its referent. On the other hand, non-notational symbol systems, project the essential proximal stimuli that would have been projected by the referents. This isomorphism between symbol and referent, characteristic of highly non-notational systems, allows learners to gain meaning through basic perceptual processes used to interpret the external world.

The assumptions regarding how people learn from notational and non-notational symbol systems have implications for instructional media research which are characteristic of extroverted approaches to perception. Instruction with highly notational symbol systems requires that the learner possess a thorough understanding of the syntax and semantic of the system before learning can take place. Instruction with highly non-notational symbol systems relies on the learners' "natural" ability to mediate the invariant qualities in sensory information. This implies that message designer's should be aware of the invariant qualities implicit in non-notational symbols and base instructional design on principles which govern their structure.

Extroverted theories have provided insights for designing messages which exploit existing mental processes to teach specific concepts (Fleming & Levie, 1984). Nonetheless, they are not particularly useful when the goal is to develop or elicit perceptual processes. There is evidence that perceptual experience is required during the early critical phases of development in order to establish normal perceptual abilities (Blakemore & Cooper, 1970; Gregory, 1977). However, the basic perceptual processes, required to recognize invariant qualities, appear to develop naturally during the course of normal humans development (Hochberg & Brooks, 1962; Movshon & Van Slyter, 1981). Introverted theories may provide a more fruitful basis for relating perception to learning because they assume that the learner is actively involved in the construction of percepts. As Norberg (1978) explained, "If perception is regarded as a constructive process, in some degree an interpretation of the `outside' world, and not just a direct apprehension of some preexistent reality, it then becomes reasonable to inquire into the means by which perceptual judgements are formed" (p.9).

Research Based on Introverted Theories of Perception

The principles developed by the Gestalt psychologists (Wertheimer, 1923; Kőffka, 1935; Kőhler, 1947) represent some of the basic assumptions of introverted theories of perception. Gestalt psychologists believed that perception is dictated by a mental tendency toward consistency. They used the term "Prăgnanz" to describe this tendency; which has the rather vague meaning of wholeness, good, simple or regular, depending on the application. Employing a number of specifically designed drawings and objects, the Gestalt psychologists conducted experiments to identify certain principles which influence Prägnanz. These principles included tendencies to: associate parts of drawings with either a figure or ground, group adjacent parts of figures together, group similarly shaped parts together, and see continuation in broken lines. The Gestalt psychologists concluded that perception is guided by automatic or spontaneous principles of Prägnanz which transcend stimulus characteristics.

More recent introverted theories agree with the Gestalt assumption that the construction of the percept is to a large extent dependent on the nature of internal processing skills. However, they disagree with the assumption that these processes are spontaneous. Gregory (1970) and Rock (1975, 1983) believe that central mechanisms of perception often involve decision-making processes which incorporate analysis by the perceiver. For example, Rock (1975) proposed that during resolution of figure-ground problems the stimulus information is first registered centrally. This central representation is then analyzed by hypothesis forming mechanisms which take into account the possibility that the contour represents either the figure or the ground. The percept is then formed according to the most plausible solution. He further explained that reversal of percepts, which occurs when viewing ambiguous figures, such as Rubin's Greek Urn, is a reflection of the central mechanism's attempt to solve equally plausible solutions. This explanation for resolving ambiguous figures differs greatly from the one offered by the Gestalt psychologist, Köhler (1947), who explained that such reversals are spontaneously induced after a sort of neural fatigue sets in.

According to Rock's explanation, many of the central mechanisms of perception resemble processes, including problem solving, probability judgements and hypothesis testing, which are affiliated with intelligence. Because they must operate on sensory information prior to the formation of conscious percepts, these cognitive-like central mechanism of perception may serve as precursors to higher-order processes used in manipulating images. Neisser (1966) contended that perceptual anticipatory schemata influence what information is acquired, and this new information in turn modifies cognitive schemata. When new information cannot be accommodated by existing cognitive schemata, the structure of the schemata must be transformed before the new information can be absorbed (Flavell, 1977, 1979; Salomon, 1981). If the learner can be prompted to activates perceptual mechanisms which have sufficient resemblance to cognitive schemata capable of accommodating this new information, the perceptional mechanism may provide the necessary framework for accommodating the new information.

The notion that higher-order cognitive processes are somewhat dependent on the development of perceptual processes is expressed in Piaget's (1966a; 1966b) genetic epistemology theory. Piaget explained that during the preoperational stage (ages 2-7), children are egocentric in their thinking. That is, they are primarily concerned with their subjective relationship to objects and events. Preoperational children tend to concentrate on particular aspects (centration) and, for the most part, fail to integrate or reconstruct parts into meaningful wholes. They begin to use verbal and iconic symbology but are often incapable of understanding relationships, such as reversibility, that are implied by the syntax in language.

As children enter the concrete operational stage, (ages 7-11) they become more objective in their thinking. Their thought is characterized by logic and the ability to understand relationships such as reversibility. Their perception of objects also becomes more objective as they begin to move their focus away from particular details (decenter) and mediate transformational relationships. Piaget and Inhelder (1971) explain this change, from centering on particular details to a more objective view of parts relationships, in conclusions drawn from experiments with the conservation of liquid task. Preoperational children do not realize that when a fixed volume of liquid is transferred from a narrow glass to a wide glass the height of the liquid will change. This is because they center on a particular perceptual aspect, e.g., the height of the liquid. On the other hand, operational children can anticipate the change accurately because they are capable of mentally transforming the various perceptual aspects.

The conservation of liquid problem involves processes which can transform both percepts and images. Piaget believed that the ability to make the necessary mental transformation is, to a great degree, affected by the child's stage of development. But he also believed that transformational imagery processes are contingent on the child's previous exposure to, and ability in, processing similar perceptual transformations. Piaget (1966a) stated, "It is of great interest to find this event of decentration occurring at the perceptual level, because it appears in one form or another as a necessary condition for cognitive adaptation at all levels of the elaboration of knowledge" p. (365).

The assumption that perceptual processes lead to higher-order cognitive processes implies that media strategies could be designed to replicate processing skills with external media techniques. This is the proposition that Salomon (1979) used in designing research to investigate the ability of media attributes to model mental processes used in cue-attendance. Salomon conducted a study in which the zooming attribute of a camera lens was designed to supplant the mental zooming that was supposedly employed by individuals accomplished in attending to pictorial cues. He found that the zooming instruction aided subjects who initially scored low on the cue-attendance task but deterred high-initial-scorers. Apparently, the zooming instruction interfered with the functional cue-attending strategies employed by those who are good at attending to pictorial cues.

Salomon offered an innovative approach to developing mental skills with media. However, the interactions between supplantation method and aptitude points to a conceptual flaw in Salomon's agenda for research. Mental processes cannot be observed directly, they can only be inferred from behavior. If the exact nature of the target processes is unknown, it is not possible to replicate processes with media attributes. Furthermore, as the numerous Trait-Treatment Interaction studies have found, different mental processes are often used to accomplish the same task (Cronbach & Snow, 1977; DiVesta, 1975; Heidt, 1978). Adopting strategies for supplanting specific processes for specific tasks invites Orwellian uniformity in thinking without providing evidence that the supplanted processes will be accommodated by the learner's cognitive structure. A more appropriate approach is to assume that the seed of ingenuity resides within the learner and devise strategies for eliciting, instead of replicating, mental processes.

Like other process oriented research, investigations of strategies for eliciting central mechanisms of perception should provide evidence that the addressed mental process have cognitive validity. Sternberg (1983) pointed out that many of the errors which have plagued intellectual skills training programs could be avoided by establishing theories of intellectual performance which specify mental processes that have received verification outside the context of the training programs. Since a comprehensive training program involves training in several processing skills, each of the processes must be validated independently. The strategies can then be incorporated in an intellectual training program designed to address one intellectual component consisting of a number of related mental processes. The processes which fall under the general intellectual component of mental imagery are promising candidates for research investigating strategies for eliciting central mechanisms of perception.

Constructive and Transformational Imagery: Contributions to Intelligence

The ability to mentally manipulate perceptual-like or analog mental images has been linked to development of memory (Paivio, 1976; Bower, 1972), reasoning skills (Piaget & Inhelder, 1971; Bruner, Olver & Greenfield 1966; Kaufmann 1979) and creative thinking (Shepard 1978; Hadamard, 1945; Finke, 1980). The imagery process implicated in these studies require the ability to either mentally construct and/or transform memorial representations. Evidence supporting the validity of these constructive and transformational imagery processes is found in psychobiographical reports on noted thinkers (Hadamard, 1945; Shepard, 1978). Of particular interest are reports from James Maxwell on the mental processes he used while developing theories of electromagnetic radiation and by Albert Einstein on his thoughts during the development of the "Special Theory of Relativity." Both Maxwell and Einstein reported constructing and transforming images of three-dimensional physical bodies. Shepard explained that Einstein initially conceived the "Special Theory of Relativity" while imagining himself traveling at the speed of light and noting what he "observed" did not correspond to existing theories. Such imaging skills require highly abstracted yet well organized mental processes capable of constructing mental representations based on the integration of both spatial and temporal dimensions.

Validating Imagery Processes and Corresponding Central Mechanisms of Perception

Butterfield, Silida and Belmont (1980) recommended using a developmental approach to validate processes involved in intelligence. They defined process as "any aspect of cognition that changes with age or can be changed by experience" (96). Processes involved in intelligence are considered to be those that become increasingly complex and abstractly organized with age. The existence of standardized tests of intelligence which incorporate age variables is offered as evidence for the broad acceptance of this assumption.

A study of anorthscopic perceptual processes conducted by Aust (1984) provides an example of how the developmental approach can be used to validate central mechanisms of perception. Anorthscopic (abnormally viewed) perception refers to the ability to recognize figures as they pass behind a narrow slit which is oriented vertically in the center of a stationary opaque field. Recognition of anorthscopically presented figures requires the mental construction of figure percepts on the basis of spatial and temporal information. Since both the viewer and the display positions remain constant, the proximal information from the slit falls in a fixed location on the viewer's retina. Consequently, the two-dimensional properties of the figures must be constructed on the basis of changes which occur only along the slit. The processes used to mentally construct percepts from an anorthscopic display are described as perceptual because they are connected directly to proximal stimuli, as opposed to being constructed from memorial representations. Rock (1975) reported that viewers of anorthscopic displays form conscious percepts of the figures. That is, they report "seeing" faint copies of the figures while viewing anorthscopic displays.

Subjects were 20 kindergartners, 20 second graders, and 20 adult undergraduate students. Anorthscopic displays of eight familiar and eight unfamiliar figures were prepared and transferred in a random order to videotape (see figure 1 for examples). Subjects were individually tested by an observer in a distraction-free room where they sat in front of a television monitor. After each figure had passed the slit on the television monitor the observer stopped the videotape and asked the subject to point to one of 16 figures printed on a form. This forced-choice measure of recognition ability served as the dependent variable.

Analysis of recognition ability found that adults ($\underline{M}$= 15.5) recognized more figures than second graders ($\underline{M}$= 14.5), who recognized more figures than kindergartners ($\underline{M}$= 11.4). Scheffe analysis at the .05 level found a significant difference between subset one, comprised of kindergartners, and subset two, comprised of adults and second graders. Results confirmed the hypotheses that the ability to process anorthscopically presented information follows a developmental trend similar to Piagetian operations of intelligence.

A second aspect of the anorthscopic perception study investigated the effects of temporal components on the construction of the percept. Subjects were 20 adult undergraduate students. A target, designed to indicate the speed of the figure moving behind the slit (assumed speed), proceeded each of the anorthscopically presented figures. The test videotape included 27 randomly ordered anorthscopic displays (three target speeds X three figure speeds X three figures). The dependent variable, attributed length (AL), was based on the length of the figures pointed to in a set of 15 figure alternatives (five lengths for each of the three figures).

A three (target speed) by three (figure speed) by 3 (figure) factorial design was used in analysis. Results showed mean AL at slow target speed ($\underline{M}$=3.03) less than mean AL at medium target speed ($\underline{M}$= 3.44) less than mean AL at the fast target speed ($\underline{M}$=3.86), $p<.01$. In other words, the length of the identified figure increased with each decrease in target speed and decreased with each increase in target speed. These findings supported the hypotheses that anorthscopic perception can be influenced by internal temporal components involved in mentally constructing percepts.

By demonstrating that anorthscopic perception follows a developmental trend similar to Piagetian operations of intelligence, the anorthscopic perception study assisted in validating the perceptual processes involved in mediating the anorthscopic display. The similarity between anorthscopic perception and cognitive imagery skills was further established by the second aspect of the study which found that changes in assumed speed produced analog changes in the constructed percepts.

Questions Pertaining to an Agenda for Research

The media techniques used in the anorthscopic perception study are unlikely to have sufficient impact on imagery ability unless they are part of a more extensive intellectual training program. A comprehensive imagery development program might begin with recognition tasks requiring the identification of figures from successively more abstract depictions. Other strategies might address: cue-attendance, mental rotation (Shepard & Metzler, 1971) anticipatory transformations (e.g., the conservation of liquid task) or anorthscopic perception. More advanced exercises might include tasks which require the perceiver to construct three-dimensional mental representations while viewing a sequence of cross-sections depicting a two-dimensional plane as it travels through objects. A display depicting a two-dimensional plane traveling through the human brain might assist medical students in developing the necessary imagery skills for determining the location and orientation of cortical slices.

Several question pertaining to an agenda for research have arisen:

1). Is further development of schemes for classifying symbol systems and media attributes warranted? Have such schemes relied too heavily on metaphorical comparisons to verbal language (Cassidy & Knowlton, 1983)?

2). Are central mechanisms of perception more "teachable" than affiliated imagery processes because success in perceptual processing requires the immediate construction of percepts?

3). What are the factors that govern the transfer of central perceptual mechanisms to affiliated cognitive imagery processes? What are the factors that hinder transfer?

4). To what extent should media strategies depict imagery transformations? (Some successful computer simulations, such as "The Factory," depict only the before and after state of the objects. The learner must imagine the required transformations).

5). Should media strategies be designed to supplant mental processes or elicit mental processes?

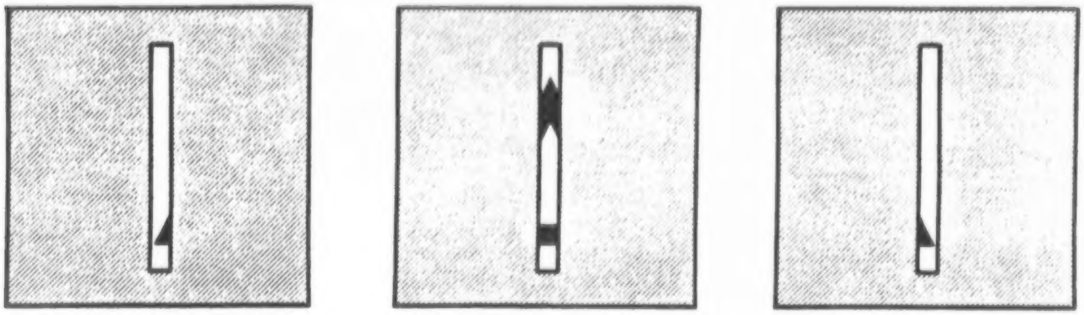
6). What are the essential differences between and among learners which impact on the success of media strategies designed to promote imagery?

7). Is the developmental approach for validating processes affiliated with intelligence sufficient? Are there other, more viable, methods for validating central mechanisms of perception?

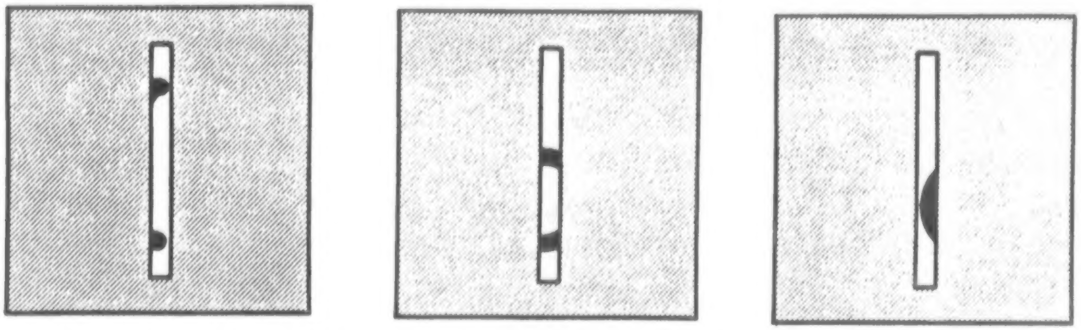
8). How should the media strategies, designed to promote imagery, be organized in a comprehensive intellectual training program? Should a developmental sequence of strategies be established?

Figure 1

The Information Projected at Three Distinct
Moments In an Anorthscopic Display



As the familiar equiangular triangle enter the slit, a small right triangle is visible. Half way through the presentation, the apex of the triangle and a small portion of the base are visible. As the triangle leaves the slit, another right triangle is seen. These three features alone may be sufficient for recognition since the viewer has a mental record for "triangle."



The information projected at comparable moments when an unfamiliar figure is presented anorthscopically. In this case the selected revelations may not be sufficient for the viewer to construct a percept of the unfamiliar figure.

References

Aust, R. J. (1984). Mental processes involved in anorthscopic perception. Unpublished doctoral dissertation, University of Washington, Seattle.

Blakemore, C., & Cooper G. F. (1970). Development of the brain depends on the environment. Nature, 228, 477.

Bower, G. H. (1972). Mental imagery and associative learning. In L. W. Gregg (Ed.), Cognition in learning and memory. New York: Wiley.

Brown, E. L., & Deffenbacher, K. (1973). Perception and the senses. New York: Norton.

Bruner, J. S., Olver, R.R, & Greenfield, P.M. (1966). Studies in cognitive growth. New York: John Wiley.

Cassidy, M. F., & Knowlton, J. Q. (1983). Visual literacy: A failed metaphor? Educational Communications and Technology, 31, 67-90.

Clark, R. E. (1983). Reconsidering research on learning from media. Review of Educational Research, 53, 445-459.

Cooper, L. A., & Shepard, R. N. (1970). Transformations on representations of objects in space. In E. C. Corterette, & M. Griedman (Eds.) Handbook of perception, (Vol. 8). New York: Academic Press.

Cornsweet, T. N. (1970). Visual Perception. New York: Academic Press.

Cronbach, L. J., & Snow, R. E. (1977). Aptitudes and instructional methods. New York: Irvington.

Dale, E. (1969). Audio visual methods in technology. (rev. ed.). Scranton, Pa: Dryden Press.

DiVesta, F. J. (1975). Trait-treatment interactions, cognitive processes, and research on communication media. AV Communication Review, 23, 185-196.

Dwyer, F. M. (1970). Exploratory studies in the effectiveness of visual illustrations. AV Communication Review, 18, 235-249.

Dwyer, F. M. (1972). A guide for improving visualized instruction. State College, Pa: Learning Services.

Finke, R. A. (1980). Levels of equivalence in memory and perception. Psychological Review, 25, 43-62.

Flavell, J. H. (1977) Cognitive development. Englewood Cliffs, N.J.: Prentice-Hall.

Flavell, J. H. (1979) Metacognition and cognitive monitoring: A new area of cognitive developmental inquiry. American Psychologist, 1979, 34 (10), 906-911.

Fleming, M. L. (1977). The picture in your mind. AV Communication Review, 25. 43-62.

Fleming, M., & Levie W. H. (1984). Instructional message design: Principles from the behavioral sciences. Englewood Cliffs, N.J.: Educational Technology Publications.

Gagnon, D. (1985). Video games and spatial skills: An exploratory study. Educational Communications and Technology, 33, 263-275.

Gibson, J. J. (1954). A theory of pictorial perception. AV Communication Review, 2, 3-32.

Gibson, J. J. (1966). The senses considered as perceptual systems. Boston: Houghton Mifflin.

Gibson, J. J. (1972). A theory of direct visual perception. In J. R. Royce & W. W. Rozenboom (Eds.), The psychology of knowing. New York: Gordon & Breach.

Goodman, N. (1968). Language of art. Indianapolis: Bobbs-Merrill.

Gregory, R. L. (1977). The intelligent eye. New York: McGraw-Hill.

Gyr, J. W. (1972). Perception as reafference and related issues in cognition and epistemology. In J. R. Royce & W. W. Rozeboom (Eds.), The psychology of knowing. New York: Gordon and Breech.

Hadamard, J. (1945). The psychology of invention in the mathematical field. Princeton, N.J.: Princeton University Press.

Heidt, E. U. (1978). Instructional media and the individual learner. New York: Nichols.

Hillgard, E., Atkinson R. C., & Atkinson R. L. (1971). Introduction to psychology. New York: Harcourt, Brace & Jovanovich.

Hochberg, J., & Brooks, V. (1962). Pictorial recognition as an unlearned ability: A study of one child's performance. American Journal of Psychology, 85, 624-628.

Hubel, D. H., & Wiesel, T. N. (1977). Functional architecture of macaque monkey visual cortex, (Ferrier Lecture). Proceeding of the Research Society of London, 198, 1-59.

James, W. (1890). The Principles of Psychology. New York: Holt.

Kaufmann, G. (1979). Visual imagery and its relation to problem solving. Bergen, Norway: Universitetsforlaget.

Kennedy, J. M. (1974). Icons and Information. In D. E. Olson (Ed.), Media and symbols: The forms of expression, communication, and education. (NSSE Yearbook). Chicago: University of Chicago Press.

Köffka, K. (1935). Principles of Gestalt psychology. New York: Harcourt.

Köhler, W. (1947). Gestalt psychology. New York: Liveright.

Kosslyn, S. M., & Pomerantz, J. R. (1977). Imagery, propositions, and the form of internal representations. Cognitive Psychology, 9, 52-76.

Lebowitz, H. W. (1965). Visual Perception. New York: Macmillian.

Levie, H. W. (1978). A prospectus for instructional research on visual literacy. Educational Communications and Technology, 26, 25-36.

Movshon, J. A., & Van Sluyters, R. C. (1981). Visual neural development. Annual Review of Psychology, 32, 477-522.

Neisser, U. (1966). Cognitive psychology. New York: Appleton-Century-Croft.

Norberg, K. (1953). Perception research and instructional technology. AV Communication Review, 1, 18-29.

Norberg, K. (1962). Perception research and AV education (introduction). AV Communication Review, 10, (Suppl. 5), 5, 3-9.

Norberg, K. (1966). Perception theory and instructional communications. AV Communication Review, 14, 301-317.

Norberg, K. (1978). Perceptual research: Does it make any difference? Educational Communications and Technology, 26, 5-13.

Olson, D. R., & Bruner, J. S. (1974). Learning through experience and learning through media. In D. R. Olson (Ed.), Media and symbols: The forms of expression, communication, and education. (NSSE Yearbook). Chicago: University of Chicago Press.

Paivio, A. (1976). Images propositions and knowledge. In J. M. Nicholas (Ed.), Images propositions and knowledge. Dordrecht: Reidel.

Piaget, J. (1966a). The mechanisms of perception. New York: Basic Books.

Piaget, J. (1966b). Genetic epistemology. New York: Columbia University Press.

Piaget, J., & Inhelder, B. (1971). Mental imagery in the child. New York: Basic Books.

Richardson, A. (1969). Mental Imagery. New York: Springer.

Rock, I. (1975) An introduction to perception. New York: Macmillian.

Rock, I. (1983). The logic of perception. Cambridge, Mass.: Bradford.

Rohwer, W. D., Jr. (1970). Images and pictures in children's learning: Research results an educational implications. Psychological Bulletin, 73, 393-403.

Salomon, G. (1979). Interaction of media, cognition, and learning. San Francisco: Josey Bass.

Salomon, G. (1981). Communication and education: Social and psychological interactions. Beverly Hills: Sage.

Salomon, G., & Clark, R. E. (1977). Reexamining the methodology of research on media and technology in education. Review of Educational Research, 47, 99-102.

Shepard, R. N., & Metzler, J. (1971). Mental rotation of three-dimensional objects. Science, 171, 701-703.

Shepard, R. N. (1978). Externalization of images and the act of creation. In B. Randhawa & W. E. Coffman (Ed.), Visual learning, thinking and communication, New York: Academic Press.

Shepard, R. N., & Podgorny, P. (1978). Cognitive processes that resemble perceptual processes. In W. K. Estes (Ed.), Handbook of learning and cognitive processes (Vol. 5: Human information processing) Hillsdale, N.J.: Lawrence Erlbaum Associates.

Sternberg, R. J. (1983). Criteria for intellectual skills training. Educational Researcher, 12 (2), 6-12.

Torkelson, G. M. (1977). AVCR - one quarter century: Evolution of theory and research. AV Communication Review, 25, 317-358.

Travers, R. M. W. (1977). Essentials of learning (4th ed.). New York: Macmillian.

Wertheimer, M. (1958). Principles of perceptual organization. In D. C. Beardslee & M. Wertheimer (Eds. and Trans.), Readings in perception. Princeton: Van Nostrand. (Original work published, 1923).

Wundt, W. (1907). Outlines of psychology. Translated by C. H. Judd. New York: Stechert.

READER THEORIES AND EDUCATIONAL MEDIA ANALYSIS

Ann DeVaney Becker, Professor
Educational Communications and Technology
University of Wisconsin-Madison
225 No. Mills St.
Madison, WI 53706

Reader Theories and Educational Media Analysis

Theories upon which most educational media research is based are usually behavioral or cognitive in nature. Even those studies which fail to state their theoretical framework, most often make assumptions which place them squarely in the behavioral or cognitive paradigm. These paradigms, while incorporating powerful psychological explanations for learning, neglect those social explanations for learning upon which so much of our knowledge is based. A few theories which incorporate social explanations for learning are those applied in the analysis of the languages of communication. Since media employ their own languages, they are ripe for such analysis. Some theories which investigate the creation and reception of media texts are structural and post structural reader theories. In fact, these theories have considerably advanced the field of media studies in England and the United States (Gitlin, 1980, Ellis, 1982, Hall, 1980, Heath and Skirrow, 1977). I believe they provide a rich vein for educational media reserachers to tap. They allow the investigation of social, cultural and historical issues which cannot be explored within a behavioral nor cognitive paradigm, therefore, in this paper I will introduce the central concepts of post structural reader theories and consider their application to educational media.

Key Concepts

Post structural reader theories developed as a reaction against structural analysis in which the media text itself is of dominant interest. Structural analysists believe that messages are encoded in the media text and the viewing process is simply one of decoding a fixed message. Critiques of structuralism have indicated the shortsightedness of such a stance. If one considers the act of communication, the media text is only one element in that process. In any communication, messages are created by a sender or author, encoded in a text and differently decoded by readers or viewers. Therefore, the sender's or author's intent, the text and the reader/viewer become important parts of the analytical equation. To overcome this theoretical and pragmatic emphasis on text, post structural analysts began to focus on the reader/viewer as the creator of meaning. They believe that a reader/viewer creates meaning when interacting with a media text which is coded and in which the author's intent is embedded. Varying reader theories, such as, deconstruction (Derrida, 1977, Bloom, 1975, Hartman, 1979), reception theory (Jauss, 1970, Ingarden, 1973, Charvat, 1959), structural poetics (Culler, 1975), and interpretive strategies (Fish, 1980) define key concepts in a similar fashion.

Just as students interpret meaning in the process of reading a book, so do they create meaning in the process of viewing a film. One might say that this is one of the central ways in which they learn from film, but the concept of viewing can be constructed in a more active fashion. It can be called reading. Since the concepts of reading and text take on new connotations in reader theories, it is best to start with their definitions.

Reading in this case would be the process of creating meaning while viewing an educational media presentation. The presentation is a communication which has been encoded in signs and symbols which remain dormant until they are received by the viewer. The viewer, therefore, not the medium creates the meaning.

Text in this case would be the word used to describe the educational media presentation. The reason for the selection of this word is twofold. Texts are items that are read. By calling an educational film or video a text, one calls attention to the active role of interpreting by the viewer, not the passive role of viewing. Text also suggests a book which has been written and constructed with careful intent. To call a film or video a text, calls attention to the fact that it has been constructed and hopefully dispels the myth of the opaqueness of visual media. It works against the notion that a camera is a window on the world.

Communities of Viewers are those readers who share membership in a social, economic, professional or other natural group and whose interpretations agree because of their membership in that group. This concept is not shared by all reader theories, but is prominent in the work of Stanley Fish (1980). Knowledge is often social and occurs because of one's membership in a group, not only because of one's individual brain function. For example, those readers who share membership in that ubiqiutous community of adolescents, read John Hughes' films of high school culture differently than do adults. Likewise, those elementary school children whose parents have refrained from supplying them with guns and war toys may interpret missles, presented as illustrations in computer programs, differently than those children who are familiar with war toys. Those high school students who have drug problems, read drug education films differently than those who do not have those problems. These are not just superficial reading differences, nor simply different reactions to a film. For example, the organization of the text gives the reader access to syntactic meaning. In other words, the appearance of a weapon next to a math problem on a computer screen does not only invite the reader to interpret the juxtaposition symbolically, but syntactically as well. It invites readers to interpret the weapon as a function of the math concept, just as they would interpret a verb in a sentence as a function of the subject. It sets up expectaions.

Paradigmatic meaning, on the other hand , is supplied by syntax patterns or codes and readers can only work with codes with which they are familiar and they are only familiar with codes that come from the worlds or paradigms to which they have access or which they have experienced, in other words, their culture. The knowledge, therefore, acquired by a high school drug user comes, in part, from a language and a practice which has specific codes and conventions. It is these codes and conventions that users employ when contextualizing the information presented in drug education films. This is a separate reading of the film not just a separate reaction.

Intertextuality has two applications. The first suggests that certain meanings of one text are created only by the existence of related texts. I will use John Hughes' films to illustrate this concept. Certain codes that are not unique to Hughes films, if read individually, are unique in combination. For example, in his first teen film, Sixteen Candles, Hughes establishes specific visual and speech codes for high school groups of "brains," "geeks," "jocks," "rich kids," and "outsiders." After this film, he never adds another category to his characterization of adolescents, therefore, he sets up viewer expectations that all his teens, with the exception of the film's hero and heroine, will be codified within one of these formulaic groups. His visual and speech codes are so effective in the first film, that he need only invoke them once or twice in the other films, before viewers can identify the group to which a character belongs. Consequently, the combination of codes in one Hughes film teaches viewers how to read his upcoming films, and they interpret plot and character development in relation to these codes. Certain meanings in one Hughes film text are created only by the existence of his other filmic texts. This is one alpication of "intertextuality".

The second application of the term stems from an extension of the term "text". It is clear that media presentations, such as film or television, may be called texts, because they have been created and encoded by authors whose intentions are embedded in the media, but there is another kind of post structural text. For example, certain adolescent groups of the 1980s have specified practices and conventions in their everyday life. They communicate messages about these shared conventions, this shared knowledge through speech, behavior, clothing, consumer habits, etc. Communications about those practices and conventions may be called a text because it has been constructed by authors, teens; contains encoded messages and is interpreted by readers, teens. It was this teen text that Hughes incorporated in his films and it is the reason for his success. (Specifically ,he incorporated the text of middle to upper middle white midwestern adolescents.) He understands and reproduces speech, clothing and some of their behaviors. Since he employs their text, this application is another example of intertextuality.

I have explained the terms "reading," "text," "communities of viewers," and "intertextuality" to provide an entree to key concepts in reader theories. These concepts along with the methods of reader theories offer educational researchers an opportunity to understand how students locate meaning in media presentations they view. To illustrate the application of a reader theory I would now like to suggest an analysis of Sesame Street.

Sesame Street and Recpetion Theory

Of the reader theories mentioned above, I prefer reception theory, because the author's or producer's role is well explored. Some theories, such as deconstruction, tend to valorize the reader and overlook the author. Additionally, reception theory offers the most practical guidlines for analysis. Some other theories provide engaging theory but little method. Reception theorists (Jauss, 1970, Ingarden, 1973) believe that any text is esentially open to interpretation, but that at specific points in time, readings of that text become "concretized" by readers whose expectations have been determined by their culture. If readers were interpreting a video text, their frame of reference for that interpretation would be created by an understanding of previous video texts, of similar themes and subjects, and by their life experiences.

How then would reception theory explain how children learn from Sesame Street? Most of the Sesame Street studies to date attempt to ascertain what a child remembers after viewing, but learning is much more than remembering. Making sense of Sesame Street, creating meaning is learning as well. Yet what would researchers have to understand before they could answer the question, "How do a specific group of viewers make sense of Sesame Street? Notice that the focus question has shifted from an individual child to a group of children. That occurs because the researcher cares to access that social knowledge which children bring to the interpretation of Sesame Street. Groups or communities of viewers often interpret a program similarly, because of what they have learned by being a member of that group. For example, a late 1980s viewing audience would read Sesame Street differently than an early 1970s audience. Over the years, the program has been valorized. After the first wave of Sesame Street research, American educators and parents finally admitted that a three year old was ready for prereading and math skills. That message can be communicated to a 1980s viewer by the manner in which some parents approach the program. Today toddlers often play with Sesame Street dolls and toys, or listen to the reading of a Sesame Street book, sometimes before they start viewing the television program. The content and structure of other television programs are often part of toddlers' knowledge. Today middle class toddlers have had to make sense of attitudes toward the program;

toys, books and dolls from Sesame Street; and the form and content of other television programs before and during the viewing of a single program. Therefore, a researcher must understand the history of the program and the culture of its viewers.

. How then can a person tap into cultural knowledge by asking the simple question of a child, "What did you remember from that program?" (I do not suggest that we ignore that question, but ask additional ones.) We know that children read Sesame Street by filtering the program through the texts from their everyday life mentioned above, through the ways in which they have made sense of the world around them. Analysts can access these texts in a number of ways; by interviewing the children themselves, by watching them watch Sesame Street, by cataloguing their TV viewing habits, by observing their play, by interviewing child psychologists, by talking to parents, by observing parent child interaction and by observing the parent buying habits for the pre school child. The objective here would be to discover enough patterns in these diverse fields of reference, so that an accurate picture of the culture of a toddler emerges. All these fields of reference need not be tapped directly, but secondary sources, books and articles may be relied upon.

The author's or producer's intent should be explored. In the case of Sesame Street that would not be a hard task, because the origination of the program is well documented. A researcher could do some historical investigation of books about the program, of files and reports from the Children's Television Workshop, and could conduct interviews with the designers and producers. Just as one could examine the 1970s Sesame Street viewer, one could also compare the producers' intentions in 1970 with their intentions today and that could be accomplished through interviews. Perhaps there would be some designers or producers who had worked on the program for the 18 years of its existence.

The program itself should not be ignored, but examined for encoded meaning. Again the opportunity would exist for historical comparison. The analyst could identify those codes in the visual text which are drawn from the world of the toddler and used to convey messages about pre reading and math. (This is similar to the comparison made between the everyday texts of adolescents and the teen films of Jonh Hughes.) The best method, I believe, for idnetifying toddler codes is still a paradigmatic analysis drawn from semiotics.

Reception theory, therefore, offers the opportunity to answer the question, "How do specific groups of viewers make sense of Sesame Street?" Reader theories in general offer us the opportunity to expand that favorite question of ours, "How does a student learn from a media presentation?", to a consideration of the culture of the student, so that we may answer the broader question, "How do students make sense of media presentations?"

REFERENCES

Bloom, H. (1975) A map of misreading, New York; Oxford University Press.

Culler, J. (1975) Structural poetics, Ithica, New York; Cornell University Press.

Charvat, W. (1959) Literary publishing in America, Philadelphia, University of Pennsylvania Press.

Derrida, J. (1977) Of grammatology, trans. by G. C. Spivak, Baltimore; Johns Hopkins University Press.

Ellis, J. (1982) Visible fictions, London; Routledge and Kegan Paul.

Fish, S. (1980) Is there a text in this class. The authority of interpretive communities, Cambridge, Mass; Harvard University Press.

Gitlin, T. (1980) The whole world is watching, Berkeley, California; The University of California Press.

Hall, S. (1980) Encoding/decoding. In S. Hall, D. Hobson, A. Lowe, and P. Willis (Eds.), Culture media and language, London; Hutchinson and Company, 128-138.

Heath, S. and Skirrow, G. (1977) Television: a world in action, Screen, 18 (2), 7-59.

Hartman, G., editor (1979) Deconstruction and criticism, London; Routledge and Kegan Paul.

Ingarden, R. (1973) The literary work of art, trans. by G. G. Grabowicz, Evanston, Illinois; Northwestern University Press.

Iser, W. (1978) The act of reading, Baltimore; The Johns Hopkins Press.

Jauss, H. (1970) Literary history as a challenge to literary theory, trans. by E. Benzinger. New literary history, 2 (Autumn 1970): 7-37.

Evaluations of Educational Microcomputer Courseware/Software: A Content Analysis of Published Reviews

Evelyn Bender
Temple University

Current affiliation:
Stetson Jr. High School
B St. & Allegheny Ave.
Philadelphia, PA 19134

Evaluations of Educational Microcomputer Courseware/Software: A Content Analysis of Published Reviews

While schools in the United States are purchasing microcomputers at an increasing rate in their response to the perceived potential of a new technology, the apparent motivating effect on students, and the advocacy of parents, there is concern about the quality of courseware being developed. One aspect of selecting courseware and other educational materials is obtaining information about their effectiveness. A standard source of information for educators and librarians has been reviews published in journals. Studies have been done which investigated published reviews of media--books, films, filmstrips, and videodiscs. However, a search of the literature did not reveal any study of reviews of microcomputer courseware. It seemed timely to study courseware reviews to find out which criteria they discussed, if reviewers agreed in their assessments, how evaluative the reviews were, and whether the reviewing policy of the journal influenced the review.

Method

The research strategy included developing an instrument that could be used for a content analysis and selecting programs that had been reviewed widely enough to provide sufficient material to analyze. Editors of journals would be contacted for information about reviewing policies.

The content analysis instrument was a composite, formed of criteria developed by organizations that evaluate courseware, for example, EPIE, Microsift, and Alberta Education. Criteria are well developed, many having been used for older forms of material, such as books, particularly in the area of content. Classification of criteria and their definitions, however, differed from form to form. The classification scheme used in the instrument closely follows that of M.D. Roblyer (1983). Each variable was carefully defined in order to form discrete categories for the analysis (Appendix A).

The variable, Student Tryout, which appears in eight out of the thirteen forms used (and in the reviewing policy of Educational Technology) has been cited in the literature as the most important factor in a good evaluation because students perceive courseware differently than adults. One fairly new criterion, Innovative Use of Computer, has been incorporated in a few forms, and attempts to differentiate the ordinary programs from the extraordinary. As a result of the pilot study conducted, a few criteria were added: Problem Solving Skills, Instructional Component, Cueing Techniques, and Monitoring.

Rating scales used in evaluation forms vary from form to form depending on whether the quality of the criterion is expressed in the item: The scale is tied to the way the criterion is written. A Likert-type scale is very commonly used. However, some forms use no ratings at all, but are entirely narrative, while a few forms ask for an overall rating. In general, the development of rating scales has been neglected in evaluation. One exception to that trend is Owston's (1985) evaluation instrument with defined scales. As a result of the pilot study, in which a Likert-type scale was not feasible, a simple three part scale was used in the study: positive, negative, or mixed (having elements of both).

Logic/problem solving courseware was chosen for study because the programs seemed to be the most innovative and would be likely to elicit more extreme resposes from reviewers. Using TESS: The Educational Software Selector (EPIE, 1985), and Digest of Software Review--Education (n.d.), the most widely reviewed logic/problem solving programs were picked. They were: Chess 7.0, Dragon's Keep, The Factory, Gertrude's Puzzles, Gertrude's Secrets, Incredible Laboratory, Pinball Construction Set, Rocky's Boots, Snooper Troops, and Troll's Tales.

Although there are many journals which review courseware, it is very difficult to pinpoint a review of a particular program. The best sources of citations of reviews proved to be three online databases: Computer Database, Microsearch, and Microcomputer Index. Other sources of citations became evident through an examination of books about software programs, for example, The Whole Earth Software Catalog (Brand, 1984), and Only the Best: The Discriminating Software Guide for Preschool-Grade 12 (Mattas, 1985). Access or bibiographic control of information concerning reviews of media have varying degrees of development, with book reviews the best developed, and microcomputer software, along with filmstrips, the worst.

The next step, of finding the reviews themselves, was also difficult, because few libraries carry a depth of journals in computing, which is where most reviews are published. Interlibrary loan was able to obtain some of the reviews--others were impossible to get, even from the publishers.

A content analysis was performed on the 147 reviews obtained. Fifty-three variables--46 evaluative and seven descriptive--were considered. Excerpts quoting reviewers' opinions of variable were recorded, many of which were incorporated into Chapter 4 of the dissertation (Bender, 1986). Ratings were recorded of reviewers' opinions--a simple positive, negative, or mixed. The data were processed to yield percentages; tables were constructed.

Results

The data obtained show that although many criteria have been developed, few are used in published reviews. Only sixteen out of the forty six evaluative criteria were used in 50% or more of the reviews. The percentage of use of a criterion ranged from a high of 76.9% for Instructional Component to 0% for Field Testing (which differs from Student Tryout in that field testing is done by the developers of the program, while student tryout is done by the evaluator). The evaluative criteria used most frequently were: Instructional Component (76.9%), Problem Solving Skills (75.5%), Visuals (59.2%), Suitable Level (57.8%), Student Ease of Use (53.7%), Motivation (68.7%), Recommendations (61.9%), and Support Materials (59.2%).

Since there is little evaluative content, published reviews of educational microcomputer programs are largely descriptive. When reviews do evaluate, they are positive in nature: most of the evaluative criteria that have been used have been rated as positive. Table 1 shows the ratings of criteria that have been used at the 50% or higher level for individual programs. Few variables have been rated as negative. Although the results of the analysis may be skewed toward the positive because the programs reviewed may be of a higher quality than the average

103

program, the results agree with research done on reviews of other media. In general, it is very typical that the better courseware programs are the ones that are reviewed. The findings agree with observations experts in the field, such as Alfred Bork (1985), have made concerning courseware reviews.

Insert Table 1 about here

Consistency of reviewers' opinions was part of the study. Since most opinions were positive, there was a high degree of consistency, although individual reviewers perceive qualities of a program differently. For example, in the reviews of Rocky's Boots, there was considerable disagreement concerning the criterion, Directions on Screen. Of the total of ten ratings, six were positive, two were negative, and two were mixed. Positive: Whole Earth Software Catalog (Brand 1984, p. 188), "The instructions are clear, thorough, and simple enough for any second grader--or for that matter, any self-conscious adult--to grasp with a little practice." Negative: EPIE (1983), "Although the developer states that this program is suitable for ages 7 and above, students between 7 and 9 will have considerable difficulty with it. For these students directions are difficult to read and follow." Mixed: Electronic Learning (Unwin, 1983), "The program does a good job of walking the player through the program directions, but when they get to the games, many children will run into problems. There should be more explicit instructions on playing these games, with examples."

A few of the variables were descriptive criteria, which comprised part of every review studied. Although all the reviews included some elements of Description and Summary, there was a wide range of detail covered. Alberta Education, EPIE, and MicroSIFT consistently provided valuable descriptive information. Because choosing software that is compatible with hardware and appropriate for the setting is confusing, especially for novices, the more detailed the information, the more helpful it is to selectors.

Another aspect considered in the study was whether individual journals used one rating predominantly. With the preponderance of positive ratings found for individual reviews, it was inevitable that the journals would reflect that positive inclination. In every journal except one, the ratings were primarily positive. The exception was Educational Technology, which had a higher percentage of negative than positive reviews (57.9% negative, 36.8% positive). Other journals that had the highest negative ratings were: CUE (Computer Using Educators), 33.3%; Electronic Learning, 20%; and The Journal of Learning Disabilities, 18.1%. In addition, it was found that some evaluation organizations had a fairly high usage of negative ratings: EPIE, 31.6%; Alberta Education, 20.8%; and California Library Consortium, 23.8%.

The investigation included finding out the reviewing policies of journals and what the relationship is between the policy and the ratings. 13 out of 32 publishers replied to the letter of inquiry. Few of the respondent journals have reviewing policies. Educational Technology is one of the rare journals that encourages negative criticism in its reviews. Again, this situation agrees with studies conducted on reviews of other media. The reviewing policy does seem to influence the nature of published reviews.

Conclusions

A review of the literature showed that reviews of media are positive and uncritical in nature. The same situation obtains for courseware reviews. A short descriptive review may convey no more information than an annotation in a publisher's catalog. Some critics have attributed this endorsement of courseware to a too cozy relationship with advertisers (Bean, 1986). Besides having a heightened sense of skepticism, the selector would be advised to look for evidence of student tryout. Although the study did not measure whether or not the evaluator mastered the program, in some reviews there were operational details that seemed to indicate that mastery of the program had not been effected. This is analagous to authors' contentions that reviewers do not read their books thoroughly.

The study showed that courseware reviews need to be improved--with more extensive descriptions and greater assessment of criteria. The language of courseware evaluation needs to be standardized--with common definitions developed. Further, although checklists have their uses, in depth analytical evaluations provide more substantial information to the reader. Software reviews function more to keep educators aware of new items than as major inputs into the selection process. At present, there is no substitute for previewing a program and obtaining input from several students in the target population. The study verifies what the literature contends: that courseware evaluation is in the early stages of its development and should evolve into a more intelligent, higher level system.

References

Alessi, S. M. (1985). Computer-based instruction: methods and development. Englewood Cliffs, New Jersey: Prentice-Hall.

Bean, E. (1986, June 16). Passing on reviews [Section 4] . The Wall Street Journal, p. 19D.

Bender, E. (1986). Evaluations of selected logic/problem solving educational microcomputer software/courseware: a content analysis of published reviews." (Doctoral dissertation, Temple University, 1986). Dissertation Abstracts International (currently being processed).

Blum, V. (1982). Evaluating instructional software for the microcomputer: an analytical evaluation procedure. Dissertation Abstracts International, 43, 3192A. (University Microfilms No. 83-04057)

Bork, A. (1985). Personal computers for education. New York: Harper & Row.

Brand, S. (1984). Whole Earth software catalog. Garden City, N.Y.: Quantum Press, 1984.

Clearinghouse of Alberta Education. (n.d.) Computer courseware evaluations. Edmonton, Canada: The Clearinghouse Curriculum Branch of Alberta Education.

Digest of Software Reviews: Education. (n.d.) Fresno, California: Home and School Courseware, Inc.

EPIE (Educational Product Information Exchange) Institute. (1984). Microcomputer courseware evaluation form. New York: EPIE.

EPIE (Educational Product Information Exchange) Institute. (1985). TESS: the educational software selector. New York: Teachers College Press.

EPIE (Educational Product Information Exchange) Institute (1983). Microcourseware PRO/file & Evaluation: Rocky's Boots. New York, EPIE.

Futrell, M. K. & Geisert, P. (1984). The well-trained computer: designing systematic instructional materials for the classroom microcomputer. Englewood Cliffs, New Jersey: Educational Technology Publications, Inc.

Heck, W. P. (1984). Guidelines for evaluating computerized instructional materials. Reston Virginia: The National Council of Teachers of Mathematics, Inc.

Hofmeister, A. (1984). Microcomputer applications in the classroom. New York: Holt, Rinehart and Winston.

Mattas, L. L. (1985). Only the best: the discriminating software guide for preschool-grade 12. Sacramento, California: Education News Service.

Media Evaluation Services. (n.d.). CAI Evaluation. Raleigh, North Carolina: State Department of Public Instruction.

MicroSIFT. (1982). Evaluator's guide for microcomputer-based instructional packages. Eugene, Oregon: ICCE (International Council for Computers in Education).

Mitzel, H. E. (1982). Encyclopedia of educational research. New York: Free Press.

NEA (National Education Association) Educational Computer Services. (1983). Guide to the software assessment procedure. Review Document #1: Courseware. Washington, D.C.: National Education Association.

Owston, R. & Dudley-Marling, C. (1986) A criterion-based approach to software evaluation. San Francisco, CA: American Educational Research Association. (Eric Document Reproduction Service No. ED 267 122)

Poirot, J. (1984). Texas Education Computer Cooperative evaluation guide. Houston, Texas: Region IV, Education Servuce Center.

Roblyer, M.D. (1983). What you should know about computer software evaluations. The Executive Educator, 5(9), pp. 34-39.

Swift's Educational Software Directory, Apple II Edition, 1983-1984. (1983). Austin, Texas: Sterling Swift Publishing Co..

Truett, C. & Gillespie, L. (1984). Choosing educational software. Littleton, Colorado: Libraries, Unlimited.

Unwin, G. & Dana, A. (1983, February). Rocky's Boots. Electronic Learning, pp. 88, 90.

Appendix A

Definitions of Evaluation Criteria

DESCRIPTIVE REVIEW

1. Description

Program name, publisher, price, hardware requirements, version number, type of program, target population, subject area, specific topic, preview available.

2. Summary

Abstract of program content, purpose of the program, educational objectives, instructional strategy, or program structure (MicroSIFT, 1982, p. 13).

TECHNICAL ASPECTS

1. Program operation

The software program is free of programming and operational errors. It will load into the computer easily and will run consistently under all normal conditions (MicroSIFT, 1982, p. 35). Pressing keys other than specified will not interfere with the running of the program.

2. Input

Required student responses (including control characters) are consistent throughout the program and appropriate for the student population. Complex input procedures are kept to a minimum unless the procedures are justified by the learning objectives (Heck 1984, p. 15). Peripheral devices (printers, light pens, paddle controllers, joysticks, etc.) are used efficiently.

3. Response time

Displays and responses have a consistent rate; there is no undue delay.

4. Random generation

Exercises, words or items will not appear in the same order each time the program is run (Blum, 1982, p. 127).

5. Technical documentation

The operation of the program, technical options and features are discussed clearly and completely in accompanying printed materials (EPIE, 1984, p. 7).

CONTENT

"Facts, terms, ideas, concepts, principles, theories, and constructs which make up the subject matter of an instructional package" (MicroSIFT, 1982, p. 9).

1. Quality of content

Factual information and terminology are accurate, complete, and up-to-date in the presentation and in questions and answers. Graphics, models, displays, and statistics are correct. Terminology is explained to the degree required by the target student population. There is an appropriate depth of information.

2. Educational value

The knowledge or skills to be learned have some relationship to school curricula or represent a value in life. The program can be utilized in an instructional situation.

3. Consistency with objectives

The content matches the objectives set by the program as demonstrated by the information required by the student to learn or by behaviors expected of the student.

4. Language

The language and grammar are correct, of the highest standard, and consistent in convention (punctuation, spelling, spacing) both on the screen (including directions and error messages) and in accompanying printed materials (Alessi, 1985, p. 376).

5. Reading level

Vocabulary, phrasing, and sentence length are appropriate for the subject level and student level.

6. Bias

The program is free of racial, ethnic, sex, and other stereotypes (Roblyer, 1983, p. 35).

7. Social characteristics

Moral issues are treated sensitively. This also applies to the format of the program, which may incorporate techniques that are questionable. For example, hangman games show capital punishment; many arcade type setups are based on war games (Heck, 1984, p. 17).

INSTRUCTIONAL DESIGN

"The instructional strategy used to implement the specific package content" (Poirot, 1984, p. 5).

1. Stated objectives

The objectives for the lesson are explicitly stated so that the student knows what the lesson covers. The objectives are considered useful and important (Alessi, 1985, p. 385), and they are stated in behavioral terms (Futrell, 1984, p. 75) when possible.

2. Prerequisite skills

The necessary abilities and knowledge needed by the student to understand the lesson are stated.

3. Testing

There is an adequate number of test items, at appropriate levels (Roblyer, 1983, p. 35). Tests place student in the program, measure student performance, reflect the objectives of the program, and are technically correct. The record of test results is accurate.

4. Clarity and logic

Concepts are presented in a well organized manner, in a recognized sequential order, using appropriate examples.

5. Instructional component

"The student gain[s] new skills or concepts from using the program" (Curriculum Review cited in Truett, 1984, p. 67).

6. Cueing techniques

"Hints/prompts/faded prompts, etc. [are] used effectively." (Clearinghouse of Alberta Education, n.d., p. 12.)

7. Feedback

"Refers to information that informs learners about the success or accuracy of their actions. Thus, feedback involves providing the learner with 'knowledge of results.'" (Mitzel, 1982, p. 1043).

Feedback is timely, nonthreatening, appropriate for the intended user. Feedback avoids reinforcing the wrong response, remediates when needed, explains why response was incorrect, does not detract from instructional message, does not slow down progress of student, and presents summary of scores at end.

8. Attention

The presentation engages the student's interest.

9. Problem solving skills

"Problem solving involves the most complex set of skills of all...instructional techniques. Going beyond simulation, it allows the learner to put into practice a range of concepts and skills necessary to solve a problem. The process as well as the solution is then seen to be applicable or adaptable to other problems with the same or similar characteristics" (NEA, 1983, p. 20)

10. Utilization of computer

The program is well suited to computer use, and is more than an expensive page turner (Hofmeister, 1984, p. 7.16). The computer is used in a dynamic, interactive way (MicroSIFT, 1982, p. 34) and "takes advantage of the computer's unique capabilities, such as response judging, graphics display, data collection, and branching" (Roblyer, 1983, p. 35).

11. Innovative use of computer

The program exhibits "unique features which distinguish it from other courseware" that are improvements in quality over previous software. (Media Evaluation Services, n.d. p. 3).

PRESENTATION

Instructional messages comprising text, graphics displays or other outputs (Alessi, 1985, pp. 314, 319).

1. Visuals

Graphics, animation, and color support and enhance the instructional process. Visuals stimulate student interest; they do not distract attention and learning. The visuals focus on important areas.

2. Sound

Sound enhances the instructional process; does not disturb others in the classroom; can be turned on and off. The quality of the sound is as good as possible.

3. Information displays

The screen is well formatted and uncluttered, without too much information presented at one time. There is adequate spacing, text is clear and easy to read. Character sets are appropriate for the students (MicroSIFT, 1982, p. 32). Text is well integrated with graphics. There is little scrolling (in which the text is put on the screen line by line with the previous lines being pushed up to make way for the new one) (Alessi, 1985, p. 75).

113

4. Menus

Options and how to choose them are clear. An incorrect choice is easy to correct by returning to the original menu. (Chances for error are lessened if pressing <return> is required after pressing a key to make a choice) (Alessi, 1985, p. 381).

5. Directions on screen

Instructions are concise and clear. Reading level is appropriate for the students and consistent with the text. "Help" procedures are available.

STUDENT USE

1. Suitable level

The content, structure, means of response, and time required are appropriate for the maturity and ability or handicap of the student. Levels of instruction exist for individual differences (MicroSIFT, 1982, p. 18).

2. Ease of use

The student understands how he is to interact with the program and can operate it in an independent manner (depending on the objectives of the program).

3. Learner control

The student can alter the rate of presentation, choose among content topics, activities, type of response, level of difficulty, or number of problems to be done. The student can review instructions, and exit the program at any time (and return to the place where he stopped).

4. Motivation

Using the software is a positive experience for the student, one that encourages him to learn. The tone of address is appropriate and effective for the student; reinforcement is positive and dignified (MicroSIFT, 1982, p. 19). After using the program, the student wants to use it again, or to learn more about the subject through a different source of information.

5. Creativity

The student is actively involved in learning. The student is encouraged to go beyond acquiring facts, to think deeply about the information and its implications, and applies the knowledge in a manner new to him. The program can handle a wide range of answers and interactions (MicroSIFT 1982, p. 19). The program provides a rich experience for the student: one that presents the process of learning as a positive human activity.

TEACHER USE

1. Ease of use

A teacher can easily operate the program without needing technical expertise.

2. Adaptability

The teacher can easily change the program through built in options to accomodate the ability level, the content, or the guidelines for use. Other choices can be made by the teacher: pace, number of problems, and criteria for mastery. This depends on the content, with spelling and math easier to control than social studies (particularly a simulation).

3. Monitoring

"A minimum amount of teacher supervision" needed while student runs the program (Clearinghouse of Alberta Education, n.d., p. 20).

4. Curriculum integration

The program fits into the course of study that is being taught.

5. Recordkeeping and management

Correct answers are tallied correctly. Recordkeeping and management are accurate, adequate, and easy to use.

REVIEW PROCESS

1. Team evaluation

More than one evaluator assesses the program. Ideally, the evaluators will have different areas of expertise (e.g. content area, instructional design).

2. Student tryout

Reviewers observe students from the intended audience use the software, take note of their problems, and interview them afterwards for their opinions (Roblyer, 1983, p. 38). (The literature singles out student review as the most important factor in evaluation.)

EVALUATION SUMMARY

1. Recommendations

The reviewer recommends purchasing or not purchasing the program (Roblyer 1983, p. 38) or revising and improving the program.

2. Strengths

Exemplary qualities in the program in relation to specific applications (Hofmeister, 1984, p. 7.18).

3. Weaknesses

Improvements needed in relation to specific applications (Hofmeister, 1984, p. 7.18).

OTHER

1. Support Materials

Accompanying printed materials are available, attractive, sturdy, meaningful, easy to use, and appropriate for the user. Documentation in the form of manuals accompanying the program includes complete descriptions of the courseware's instructional purpose, the target students, the scope of the contents, and all procedures for proper use. The manuals should be written in a clear, nontechnical style (Roblyer, 1983, p. 35). Other support materials, such as worksheets, flash cards, etc., should enhance the use of the CAI program (Hofmeister, 1984, p. 7.18).

2. Field Testing

There should be evidence that the producers field tested the program with an appropriate audience. Preferably, the field testing should be done by an independent unit (not associated with the developer) and should be used with large numbers of representative students for long periods under normal classroom conditions (Hofmeister, 1984, p. 7.18). Revisions should be based on actual findings of field testing (Roblyer, 1983, p. 35).

3. Achievement of purpose

The student learns "what the material sets out to teach, rather than merely being engaged in the process" (MicroSIFT 1982, p. 17).

4. Comparison to other programs

The program under review is assessed and compared in quality to another program.

Table 1

Criteria used at the 50% or higher level, by predominant rating

	CH	DK	FA	GP	GS	IL	PC	RB	ST	TT
TECHNICAL ASPECTS										
Program operation........		+								
CONTENT										
Educational value............		+						+	+	+
Reading level....		+								+
Social characteristics		+								
INSTRUCTIONAL DESIGN										
Clarity and logic...........								+		
Instructional component........	+	+	+	+	+	+		+	+	+
Attention........		+								
Problem solving skills...		+	+	+	+	+		+	+	+
Utilization of computer......								+		
PRESENTATION										
Visuals..........	+	+	+	+	+	+	+	+	+	+
STUDENT USE										
Suitable level...	+	+	+	+	+	+		+	+	+
Ease of use......	+	+	+	+			+			+-
Motivation.......	+	+	+	+	+	+	+	+	+	+
TEACHER USE										
Monitoring.......		-								-
EVALUATION SUMMARY										
Recommendations..	+	+	+	+	+		+	+	+	+
OTHER										
Support Materials........	+-	+-	+	+-	+	+	+	+	+	

+ = Predominantly positive
- = Predominantly negative
+- = Equally positive and negative

CH = Chess 7.0	IL = The Incredible Laboratory
DK = Dragon's Keep	PC = Pinball Construction Set
FA = The Factory	RB = Rocky's Boots
GP = Gertrude's Puzzles	ST = Snooper Troops
GS = Gertrude's Secrets	TT = Troll's Tale

MAIS: An Empirically-Based Intelligent CBI System

Dean L. Christensen
Control Data Corporation
Box 1249
Minneapolis, MN 55440

and

Robert D. Tennyson
University of Minnesota
178 Pillsbury Dr. S.E.
Minneapolis, MN 55455

January 1987

Paper presented in the symposium, Research in Computer-Based Instruction: Implications for Design, Chair, Halyna Hajovy, at the annual meeting of the Association for Educational Communication and Technology, Atlanta, GA (February, 1987).

MAIS: An Empirically-Based Intelligent CBI System

Dean L. Christensen
Control Data Corporation

Robert D. Tennyson
University of Minnesota

The past 15 years have seen an increasing growth in the use of computer technology in education and training. However, improvements in learning as a result of using this technology have not yet been realized (Clark, 1985). A major obstacle in the lack of learning improvements is the failure of instructional designers to successfully integrate learning theories with the unique attributes of computer technology (Petkovich & Tennyson, 1984, 1985). Typically, computer-based instructional design strategies have been univariate in applying learning theories; relying mainly on the use of methodologies found in non-technology assisted learning systems instead of fully employing the computer's capabilities. The conventional instructional strategies for computer-assisted instruction (CAI) include drill and practice, tutorials, games and simulations (Allessi & Trollip, 1985). In terms of employing computer capabilities, the use of graphics in games and simulations are well developed but with minimal direct influence in improving learning. However, the capabilities of computer hardware and software design make it possible to develop learning environments that can integrate a range of instructional strategies currently known to improve learning as well as making it possible to add new strategies.

Demonstration programs in education using artificial intelligence/expert systems methods have shown that the computer's more powerful attributes can be applied to instruction (Tennyson & Park, in press). These few prototype ICAI systems, (e.g., SOPHIE, SCHOLAR, WUMPUS, and others), however, continue to limit themselves to the use of one instructional strategy or learning variable within their tutor models. The focus of the developers for the ICAI prototypes has been on how to more fully employ the power of the computer by applying intelligent software programming techniques. However, even with extending the use of such computer attributes, a major ICAI limitation is still the unidimensional approach to learning and, therefore, the use of one instructional strategy regardless of the learning need and individual differences (e.g., the Socratic method used in many ICAI programs). In summary, the educational applications of computers have not in large part been fully realized because of both the apparent narrow use of learning theories and instructional strategies and the failure to fully exploit the power of the computer (see also Seidel, 1978).

My research objective, as focused in my research program for the Minnesota Adaptive Instructional System (i.e., the MAIS), is to empirically investigate generalizable instructional variables which are clearly defined within an educational psychology perspective. My goal, along with my colleagues, is to significantly contribute to instructional theory and practice such that instructional system developers will have appropriate variables by which to design and implement good instruction.

MAIS Research Program

The goal of our programmatic research program for the MAIS has been to investigate instructional variables and conditions that improve learning through the use of adaptive instructional strategies. To accomplish this research goal, we have extended the research focus of the MAIS in two important ways.

-First, by initiating research in the integration of individual difference variables within the concept of the student model. This was done by extending the learner assessment process to include a cognitive model (e.g., intelligence, aptitude, achievement) and an affective model (e.g., motivation, perseverance, personality) along with a student memory model. The elaborated student model is integrated at the curricular level with the knowledge base to provide the means for iteratively updating the adaptive instructional strategies at the instructional level. An important task in this regard has been the design of an expert tutor model capable of developing for each student different perspectives on the the prescribed instruction.

-Second, by testing instructional variables associated with the learning conditions of verbal information and cognitive strategies (Gagne, 1985). In our early investigations (reviewed in Tennyson, Christensen, & Park, 1984), the MAIS research program tested nine instructional variables directly related to the learning of intellectual skills and conditional information (i.e.,concept and rule learning) (see also Tennyson & Christensen, in press). Our more recent work, for example, is looking at the use of adaptive simulation variables to improve both content acquistion as well as development of cognitive strategies (i.e., higher-level thinking skills). Implied in this reseach effort is the continued development of the MAIS expert tutor model at the instructional level. With the integration of the curricular expert tutor model, we are able to extend the formal heuristic methods of the inference engine of the MAIS to the more advanced methods of inference making offered by informal heuristic methods (Fisher, 1986).

Our current research effort focuses on the study of instructional variables and conditions on a longitudinal basis, so as to further develop the MAIS to include the additional management requirements for the curricular level. Thus, the MAIS provides us with the opportunity to study the integration of the curricular component with the instructional component. The iterative relationship between the two components provides a means for refining both the curricular as well as the instructional needs per individual student. The basic theoretical model of the expanded MAIS is presented in Tennyson and Park (in press).

MAIS: Adaptive Instruction

Also, we distinguish here between individualized instruction and self-instructional teaching. The former refers to how students are assessed and assigned instruction while the latter is a method of instruction. An integral condition of the research-based intelligent management system of the MAIS is that it adapts to individual learner needs based on assessments occurring externally and internally to the instruction. Typically, assessments are made prior to and/or after the instruction. Our research findings show that student assessment during learning is a powerful method of adapting instruction to the student's moment-to-moment learning needs (Park & Tennyson, 1980). Furthermore, the system employs an iterative method of intelligence such that the management decisions will become increasingly refined the longer the student is in the learning environment. This form of iterative updating of the decision making process is in direct contrast to most current ICAI methods of reactive decision making.

Another important feature of the research-based MAIS, is that it employs a cognitive psychology approach to the selection of instructional strategies (Tennyson & Cocchiarella, 1986). Basically, the MAIS deals with the concepts of learning, memory, and cognition within the framework of the curricular and instructional levels of education and training. That is, the MAIS defines instructional variables and conditions that predictably improve (a) the acquisition of information, (b) the storage and retrieval of knowledge, and (c) the creative and thinking processes. The potential of the computer in terms of its power and speed for variable manipulations and calculations makes it possible to construct an AI instructional system capable of handling the complexity presented by the application of an instructional theory that accounts for learning, memory, and cognition.

Design of the MAIS

The MAIS is designed around the three concepts of learning, memory, and cognition within the conditions of curriculum and instruction. Figure 1 presents a graphic representation of the current version of the MAIS. Within the curricular or macro level, we define variables that relate directly to the concepts of memory and cognition, while at the instructional or micro level, we define variables that relate to the concept of learning. The variables within the macro component establish the conditions of curriculum while the micro component adapts the instruction to meet moment-to-moment individual student learning needs. Both components interact in an iterative fashion such that the initial conditions of instruction established by the expert tutor model in the macro adapts at the micro level according to learner progress and needs in learning.

Insert Figure 1 about here

The basic research goal the MAIS project has been to approach intelligent management systems from a curricular level instead of the conventional, instructional-only level. Typical designs for computer-based management systems have rarely expanded the function of management beyond that of student record keeping and have operated with branching routines composed of finite-sets of possible remediations and options.

A primary purpose of the MAIS research program has been to investigate individual difference variables that would contribute to the initial conditions of instruction within the specifications of a given curriculum. A second purpose has been to investigate variables and conditions by which adaptive instructional systems can iteratively update the conditions of instruction as the individual student progresses through the curriculum. The term "dynamic" is used to describe this relationship between the macro- and micro-level expert tutor models such that as a learner progresses through instruction, appropriate information can be continuously sent back to the macro-level to constantly refine the decision making for the succeeding conditions of instruction: In other words, the MAIS employs variables that learn how to improve instructional decision making.

Macro-Level

Figure 1 shows the two main variables of the macro-level component. The variables--cognitive model, affective model, and memory model--represent areas of individual differences within the context of a student model. Research findings have shown that each of these variables have differing effects on learning and, therefore, need constant adjustment based on the curricular knowledge base. The expert tutor is the decision making component of the system. The function of the expert tutor model is to establish the conditions of instruction within the context

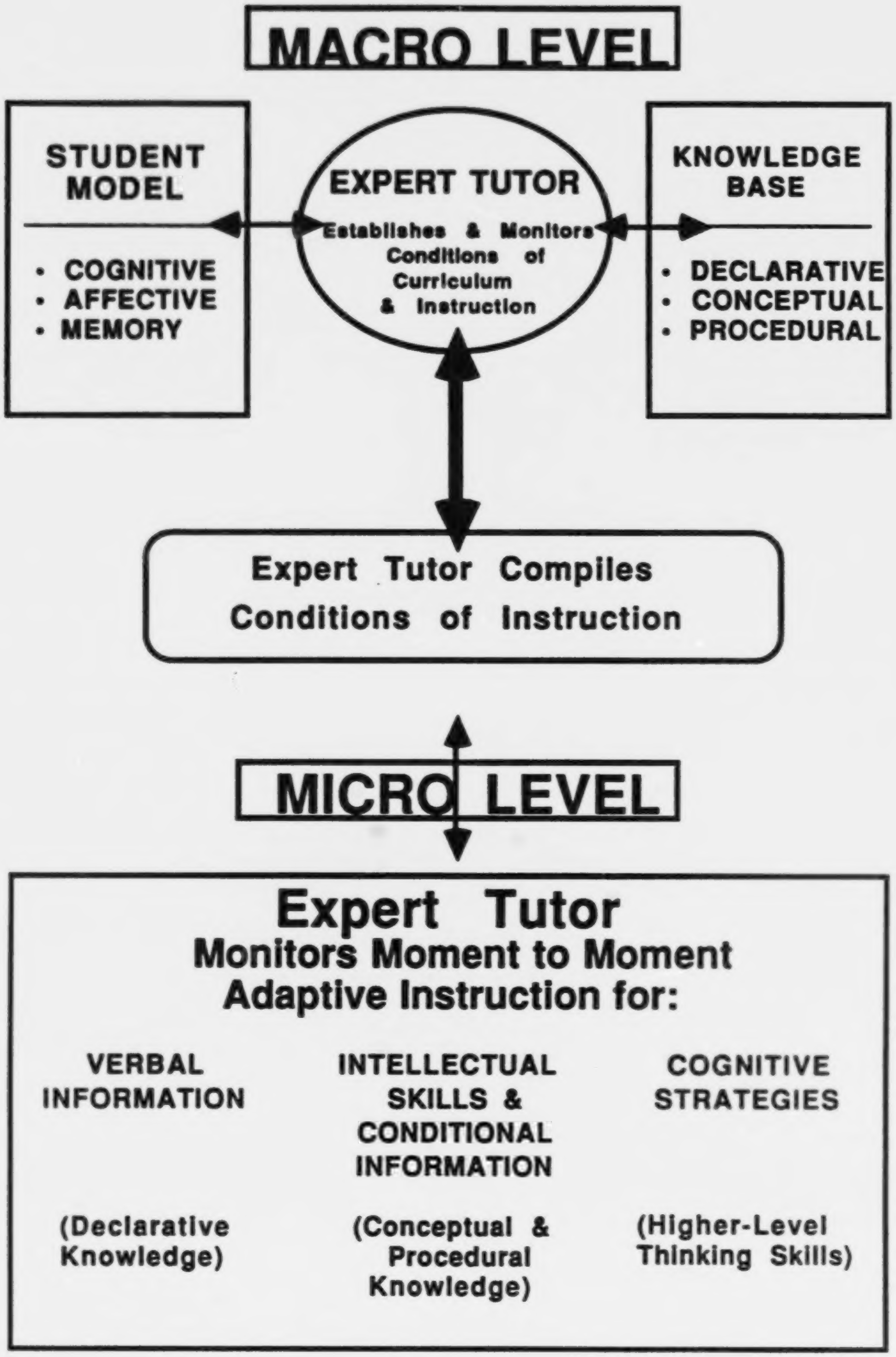

MACRO LEVEL
STUDENT MODEL
• COGNITIVE
• AFFECTIVE
• MEMORY
EXPERT TUTOR
Establishes & Monitors Conditions of Curriculum & Instruction
KNOWLEDGE BASE
• DECLARATIVE
• CONCEPTUAL
• PROCEDURAL
Expert Tutor Compiles Conditions of Instruction
MICRO LEVEL
Expert Tutor
Monitors Moment to Moment Adaptive Instruction for:
VERBAL INFORMATION
(Declarative Knowledge)
INTELLECTUAL SKILLS & CONDITIONAL INFORMATION
(Conceptual & Procedural Knowledge)
COGNITIVE STRATEGIES
(Higher-Level Thinking Skills)

FIGURE 1. Diagram of the MAIS Environment.

of the curriculum. The macro-level expert tutor model compiles the initial parameters of instruction, with the micro-level expert tutor model making necessary adjustments at the moment of learning.

Micro-Level

The instructional level of the MAIS deals directly with student learning at the verbal information, intellectual skills, conditional information, and cognitive strategies objectives of learning. From the nine instructional variables shown in Figure 1, an instructional strategy is compiled from the macro-level expert tutor model. The instructional conditions appropriate for cognitive strategies learning are discussed in an article by Tennyson, Thurlow, and Breuer (in press). Verbal information learning is discussed in Goldberg and Tennyson (1987), therefore, we will also not elaborate here on the unique conditions required for the learning of declarative knowledge. Given the scope of this article, we will discuss our research efforts by focusing only at the intellectual skills/conditional information level of learning objectives. That is, the primary instruction for knowledge acquisition. Cognitive strategies focuses on development and improvement of thinking skills.

Briefly, the nine instructional variables that form the possible meta-instructional strategies for the improvement of knowledge acquisition are as follows (see Figure 1):

-Worked Examples. The learning of complex concepts and rules can be improved if the student understands the underlining principle(s) of the information to be learned. Learning declarative knowledge is the purpose of expository instruction where best examples are presented to show attributes or procedures and the context of the application of the concept's or rule's underlining principles. The computer enhances this form of expository instruction by requiring the student to use input devices to pace the elaboration materials rather than just presenting directly the solution.

-Amount of Information. To improve the efficiency of instruction, the MAIS employs a conditional probability statistic to determine when a student reachs mastery. This variable continously monitors student progress in learning so as to provide sufficient information for attainment of concept mastery. In cognitive psychology terms, this variable focuses on procedural knowledge development.

-Sequence of Information. In the learning of coordinate concepts and rules, many errors of misconception can by prevented by the way the information is sequenced. The sequence heuristic of the MAIS is based on the psychological principles of under- and overgeneralization, not a random or branching format favored by conventional ICAI and CAI programs. The sequence heuristic also improves development of a schematic structure in memory so that conceptual knowledge is developed.

-Format of Information. An important principle of good teaching is to engage students as soon as possible in the process of decision making or problem solving. For each student, however, this point in time differs because of the level of knowledge understanding required to solve problems. The purpose of this variable is to monitor the learning need for additional expository information to ensure adequate declarative knowledge formation. Thus, if a student shows during problem solving situations the need for additional declarative understanding, additional expository instruction can be presented.

-Learning Time. An important characteristic of an expert tutor is the ability to monitor student learning in reference to efficient use of time. That is, the tutor knows when to interact with the student so as to provide assistance. For example, when first trying to solve a problem, the student indicates by not responding that they need help, the tutor offers assistance instead of trying to force the student to make a solution and therefore a possible error. The purpose of this variable to be a more active rather than passive computer-based tutor as is typical in conventional ICAI and CAI. This variable is primarily concerned with the formation of conceptual knowledge as contrasted with procedural knowledge development.

-Corrective Error Analysis. Helping the student to understand a mistake is the purpose of this variable. Too often instructional help is not directly related to the learner's specific problem, thus the student is given excessive information which might even mask or hide the learning problem. This is especially the case in learning more complex concepts and rules. In most situations the form of analysis is content specific, however, the important concern is to design a system that can identify possible specific errors rather than the typical CAI method of feedback and branching.

-Mixed Initiative. A major short-coming of technology-based instructional systems is their ability to allow for student questions. With this variable, it is possible for the student to query the MAIS. For example, if the student does not understand a given procedure or needs an elaboration of some given attribute, they can ask the system. The MAIS then forms a dialogue with the student to understand the student's question. This is another way to help in the formation of conceptual knowledge.

-Advisement. An underlining principle of the MAIS is that the student is making progress in learning towards mastery. Because the student is also involved in various forms of decision making and is putting forth effort in learning, the student needs to be continously informed of the progress. To accomplish the goal of informing the student of their progress and to even inform them of need, the MAIS advises the student of both their current progress and the necessary instruction to reach mastery. Because this is an adaptive system, changing from moment-to-moment, advisement is provided concurrently with the instructional activities.

-Embedded refreshment and remediation. Learning within a domain of information usually implies making connections between concepts and rules. Most often the learning of connections, and therefore the schematic structure of the domain, is made by the student in memory. However, when the learning of new information requires the connection to prerequiste knowledge and the student cannot retrieve that knowledge, they need help. The purpose of this variable is to sense this need and provide the appropriate help. If the need is only for help in making the connection (i.e., the student knows the prerequisite knowledge), information on the prerequisite knowledge is presented in an expository form at that point. The term embedded refreshment is used to describe this process of helping the student recall the specific prerequisite knowledge at the moment they need to make the connection. If, however, the student needs more than just recall, but needs relearning, remediation is provided.

The expert tutor model at the micro-level adapts continously the meta-instructional strategy compiled by the macro-level expert tutor. Student learning outcomes are iteratively returned to the macro-level to further enhance the succeeding instruction.

Summary

Our concern in the MAIS research program is not to just develop a prototype system (as in the conventional ICAI research methods of tool making), but to empirically investigate the relationships between the variables of the learner model and how that relationship, along with the integration with the curricular knowledge base, enhances the instructional strategy decision making at the micro-level. In other words, in contrast to conventional ICAI research which seeks to test software intelligence techniques, we seek to investigate variables that can intelligently improve learning.

We are continuing to investigate a research-based intelligent learning system that can on one hand provide an evaluation of each student (i.e., a highly information rich student model) and, on the other, can be directly associated with the instructional prescription process. We are doing this within the framework of AI methods that will assist in the improvement of the system's inferential ability by adding the concept of system "discovery." That is, the proposed system will not only assess students prior to and continuously during learning, but will also improve its inferential ability by itself learning.

In summary, the MAIS research and development program focuses on the study of intelligent learning systems from an educational research paradigm, with variables and hypotheses directly related to the improvement of learning through the use of adaptive instructional methods. To accomplish this goal, we integrate where appropriate, variables and conditions from a wide range of disciplines and fields of study, including cognitive psychology, developmental psychology, computer science, management information sciences, as well as numerous fields in educational psychology (e.g., evaluation and measurement, reading, and instructional technology and design).

Currently, we know a lot about human learning and, in specific situations, we can actually show how a given variable or condition of instruction can significantly improve certain types of learning. However, the large number of instructional variables and strategies cited in the literature show that learning is a complex phenomenon, requiring more than the generalizable application of one or two strategies. Our research demonstrates that with computer technology, it is now possible to make use of the wide range of instructional variables to develop meta-instructional strategies to improve learning within specific needs. Through the use of AI methods, sophisticated management systems can be developed to make use of the known means to improve learning in cost-effective systems. Our basic research program will extend the work currently being done on the MAIS such that a total, technology-assisted learning system can be designed and tested. It will provide the knowledge base by which current educational and training systems can be adapted and future systems can be designed.

References

Allessi, S., & Trollip, S. (1985). Designing computer-based instruction. Englewood Cliffs, NJ: Prentice Hall.

Clark, R. E. (1985). Evidence for confounding in computer-based instructional studies: Analyzing the meta-analysis. Educational Communication and Technology Journal, 33, 249-262.

Fischer, K. W. (1980). A theory of cognitive development: The control and construction of hierarchies of skills. Psychological Review, 87, 477-531.

Fisher, E. M. (1986). Building AI beyond closed doors. Datamation, August 1.

Gagne, R. M. (1985). Conditions of learning. 4th Ed. New York: Holt, Rinehart, & Winston.

Park, O., & Tennyson, R. D. (1980). Adaptive design strategies for selecting number and presentation order of examples in coordinate concept acquisition. Journal of Educational Psychology, 72, 362-370.

Petkovich, M. D., & Tennyson, R. D. (1984). Clark's "Learning from media": A critique. Educational Communication and Technology Journal, 32, 233-241.

Petkovich, M. D., & Tennyson, R. D. (1985). A few more thoughts on Clark's "Learning from Media." Educational Communication and Technology Journal, 33, 146.

Seidel, R. J. (1978). Learner control of instructional sequencing within an adaptive tutorial CAI environment. Instructional Science, 7, 37-80.

Tennyson, R. D., & Christensen, D. L. (in press). MAIS: An intelligent learning system. In D. Jonassen (Ed.), Instructional designs for microcomputer courseware. Englewood Cliffs, NJ: Erlbaum.

Tennyson, R. D., & Cocchiarella, M. J. (1986). An empiricially based instructional design theory for teaching concepts. Review of Educational Research, 56, 40-71.

Tennyson, R. D., & Park, O. (in press). Artificial intelligence and computer-based learning. In R. M. Gagne (Ed.), Instructional technology: Foundations. Hillsdale, NJ:

Erlbaum.

Tennyson, R. D., Park, O., & Christensen, D. L. (1985). Display time interval and response-sensitive sequencing as instructional design variables in concept-learning using computer-based instruction. Journal of Educational Psychology, 77, 481-491.

Effects of Using On-Screen Learning Aids and Reading Performance

Chu, Hsiang-Chi, Julie

University of Minnesota

Running head: ON-SCREEN LEARNING AIDS

Abstract

This study was designed to investigate variables and conditions that directly influenced the learning of computer-presented expository text. On-screen underlining was used as a learning aid to increase a learner's "mindfully" processing information. Three learning conditions were designed: self-generated underlining, program-provided underlining, and optional control of the underlining. In addition, this study also examined the effects of intervening variables such as learning style, amount of invested mental effort (AIME), perceived task difficulty (PTD), time-on-task (TIME), compared AIME with others after learning (compared AIME), self-judged reading ability, and amount of experience with computers. AIME referred to the "number of nonautomatic mental elaborations applied to a unit of material" (Saloman, 1984). Twenty seven subjects participated in this study. Stepwise multiple regression analysis indicated that compared AIME, learning style, and time-on-task are the best predictors of reading performance. There were no significant differences of the reading performance among self-generated underlining group, program-provided underlining group, and the optional-control group.

Effects of Using On-Screen Learning Aids and Reading Performance

In the 1960s, some writers claimed that print was a dying medium (Balajthy, 1986). Print would be totally replaced by electronic text (Rosch, 1980). However, research has indicated that subjects reading material from a computer not only spent more time than subjects reading the same material from print (Muter, Latremouille, & Treuniet, 1982), but also performed worse (Happner, Anderson, Farstrup, & Weiderman, 1985). Therefore, most of the educators believed that the computer will never replace print as a delivery medium to present information. Nevertheless, text presentation still plays an important role in all types of computer-based instructional (CBI) lessons. Even complexity, sophistication, and the amount of presented information in each lesson may vary. It is important then, to find out what factors cause the differences mentioned above, and how reading performance on computers can be improved. A number of factors that influenced reading performance on computers have been identified. These include the resolution of the computer screen display, the type or the spacing of the font (Merrill, 1982), etc. In addition to these surface features, one possible explanation of the differences in reading performance is that while learning from a computer, the computer does not provide learners with the options to apply typographical or organizational learning aids to facilitate their information acquisition. Therefore, information processing is shallower (Craik & Lockheart, 1972), and memory trace is weaker than reading from print. Thus, in this study, it was my intention to investigate whether reading performance can be improved by making on-screen application of selected learning aids easily accessible to the learners.

There are many techniques which have been suggested for aiding text comprehension, such as underlining key concepts (Richards & August, 1975), adding an advance organizer (Ausubel, 1968), taking notes (Pepper & Mayer, 1986), or summarizing (Brown & Day, 1983). In the present study, underlining was selected as a learning aid for its ease of application in computer-based text and time efficiency. In addition, research indicated that while underlining, students seemed to concentrate more on the tasks and recognized/recalled more about these intentionally learned tasks later (Coles & Foster, 1975; Dosher & Russo, 1976; Glynn & DiVesta, 1979; Richards & August, 1975).

Researchers have used various cognitive approaches to explain this phenomenon. Cashen & Leicht(1970) stated that "making materials conspicuous by underlining serves the function as presenting the material as an advance organizer." Rigney

(1978, 1980) suggested that a learning aid such as underlining can make learning become more "conscious." Hyde & Jenkins (1969) indicated that intentional learning has better effects on word recognition than incidental learning does. Other researchers (Mayer, 1975, 1984; Rothkoph, 1970; Wittrock, 1974) have explained this phenomenon using the "generative effect", which means that by underlining, a learner is able to relate actively the material to prior knowledge.

This study was also designed to investigate the effects of the following intervening variables: AIME, perceived task difficulty, and learning style.

Amount of Invested Mental Effort (AIME)

It is generally perceived that a major advantage of CBI programs is their great potential to adapt systematically to learners´ individual needs and abilities. In these programs, learners may control the pace, sequence, and depth of study (Gay, 1986). However, these programs have not yet led to optimal performance (Snow, 1983; Crono & Mandinach, 1983). Saloman (1985) proclaimed that a computer´s source of success does not lie only in its attributes, but also in how "mindfully" (amount of effort invested) learners come to handle them. The term amount of invested mental effort (AIME), defined as the number of nonautomatic elaborations applied to a unit of material, was used to indicate the degree of "mindfulness" (Saloman, 1984). In the present study, it was hypothesized that students who generate underlining themselves after reading would invest greater amounts of mental effort, and outperform subjects receiving underlining passively from the program. In addition, the AIME was also influenced by the perceived task difficulty (PTD). When facing a complex, ambiguous, incongruent, or novel stimulus, learners usually spent more time on the task, and reported that more effort was invested (Anderson, Reynolds, Schallert, & Goetz, 1977; Bobrrow & Collins, 1975; Lepper, 1983; Pittman, Beggiano, & Ruble, 1983).

Learning Style

Learning style referred to how learners perceive, interact with, and respond to the learning environment (Keefe, 1979). Kolb (1981) proposed an experiential learning model which has integrated the abstract and concrete as well as the active and passive characteristics to explain adult learning processes. He conceived learning as a four stage cycle. In order to obtain new experiences, the learner needs to first, actively involve in new experience--concrete experience (CE); secondly, reflect on the experience from various perspectives--reflective observation

(RO); thirdly, formulate abstract concepts into logically sounded theories--active conceptualization (AC); and finally, be able to apply these new concepts and form generalizations--active experiment (AE). Although this model is cyclical and progressive in nature, Kolb and others have found that highly individualized styles of information utilization are developed on each of these bipolar dimensions.

According to aptitude-treatment interaction (ATI) effect, individuals with different aptitudes learn differently under different situations (Cronbach & Snow, 1977). Thus, it was hypothesized that subjects with an active type of learning style would learn better under self-generated learning aid condition, while subjects with a passive type of learning style would learn better under program-provided situation.

In summary, this study was designed to investigate the following hypotheses:

(1) Self-generated underlining leads to better reading achievement than program-provided underlining.

(2) Active type of learners benefit more in the self-generated underlining condition while passive type of learners benefit more in the program-provided underlining condition.

(3) AIME, PTD, and learning style are valid determinants in predicting the reading performance.

(4) Subjects in the program-provided group should perform better on the test items that are relevant to the underlines provided in the treatment.

Methods

Subjects

Posters asking for participants were posted at the University of Minnesota. Twenty seven students (thirteen undergraduate and fourteen graduate) participated in this study. Each subject was paid $5 for their participation.

Design

A completely randomized blocking design was used in this study. The blocking variable was learners' learning styles. The independent variable consisted of the following three levels: self-generated underlining, program-provided underlining, and optional control of underlining. In the self-generated underlining group, underlining of the prose passages was generated by the learners. In order to proceed to the next screen, learners had to underline at least one word. There was no limit to the amount of allowed underlining. In the program-provided underlining group, underlining of the prose passages was provided by the experimenter. Finally, in the optional-controlled group, learners were asked to underline the key words by themselves first. However, if they could not figure out the key words or wanted to compare their own underline with the experimenter´s, they were allowed to press a "HELP" key to have the word underlined for them. The treatments were parallel in all respects except in manipulation of the independent variable--control of underlining.

The dependent variables were the correct scores on the posttest and time-on-task.

Learning materials.

Each of the three treatment groups received the following materials on the computer: (a) An introductory lesson explaining the objectives of the program and the length of each passage; (b) pages of directions on how to use the function keys to proceed through the lessons. In addition, demonstration on how to use the underlining key was given to the subjects in the self-generated and program-provided groups. Subjects in the optional-control group were also given the instructions on how to use the "HELP" key; (c) a practice unit, different in each group, familiarizing the subjects with the special keys and screen display; and (d) two text passages presenting the information to be learned.

A paragraph of text on "Amish" people (Brozo, Schmelzer, & Andrews, 1984) was used as the practice text for all the groups. Two expository test passages were given to the subjects. The first passage, "Ancient Greek Poets", was adopted from the Nelson-Denny Reading Test Form A (1960). It describes how the poetic form has changed during the six hundred years since Homer´s death. This passage had 684 words in 31 sentences and nine paragraphs, and was presented in six computers screens. In the posttest, eight questions were adopted from the original test. The two remaining items were written by a panel of three graduate students. The second passage "Tsunami", i.e. tidal waves, was adapted from the book "Setting the Pace" (Brozo, Schmelzer, & Andrews, 1984), and describes the formation of sea waves. This passage had 758 words in 33 sentences and 15 paragraphs, and was presented in eight computer screens. The original 10 test items were partially revised by the experimenter and a panel of three graduate students.

The design of the screen display followed the principles suggested by Allesi & Trollip (1985). The text was in a form of 60-columned, double-spaced, and upper and lower cases screen display. Each screen had 11 text lines in maximum. When a screen could not contain a complete paragraph, then this paragraph was moved to the next screen. Underlining used in the program-provided group representing the macrostructure of the text, was developed following Kinstch & Van Dijik's model (1978). Each screen had only one central idea underlined. This information was tested on the posttests later on. To eliminate the possible confounding effects, the treatments were designed so they did not allow the subjects to review the previous screens, take notes or erase the unwanted underlines.

Measures

The following measures were used in this study:

Learning style. Subjects were tested for their learning styles using Kolb's Learning Style Inventory (1985). This questionnaire includes twelve items and measures learners by using two bipolar variables: abstract conceptualization (AC)/concrete experience (CE) and active experimentation (AE)/reflective observation (RO). The internal reliability measured by Cronbach's α . For AE, $\alpha = .82$; for RO, $\alpha = .73$. Ipsative scaling was used in this inventory. Generally, a subject's learning style is identified by the combination of scores on both AC-CE vs. AE-RO. However, in this study, only the scores on AE/RO were used because it was assumed that the effects of on-screen underlining directly related to learners' preference for learning through active generating or passive observing the learning aid.

Posttests. Five factual and five comprehensive multiple choice test items were designed for each passage to test reading retention. For each text passage, the posttest was divided into two subsets: (a) a relevant subset containing five factual items related to the content of the program-provided underlining. (b) The other subset dealing with comprehensive items not covered by underlining. The factual items were designed to test if intentional learning would produce better performance.

Self-report questionnaire. This questionnaire was designed to measure each learner's perception on the difficulty and interest levels of the passages, the AIME, the degree of concentration, and the AIME compared with other learners, etc. Subjects were asked to respond to statements such as "This is a difficult passage," "I tried hard to understand this passage," " I concentrated while reading the passage," "I think that other readers must have tried harder than I did to understand this passage." Each item was scored on a 5-point Likert scale.

Procedure

The study was conducted in a computer lab administered by the College of Education. Two weeks before the study, subjects were tested to determine their learning styles, then randomly assigned to three treatment groups. On the first week, the subjects came to the computer lab at their own selected time. Before reading the on-screen prose passages, subjects filled out a demographic questionnaire, which asked them to indicate their perceived reading level (good, fair or poor), time spent on reading per week, and amount of experiences on computers. They were then asked to read the learning materials, presented by IBM XTs with color monitors. Subjects were allowed sufficient time to complete the reading. Then they were asked to stop and answer four questions on a separate printed page. These questions asked the subjects to evaluate the difficulty and interest levels of the passage and their AIME and concentration while reading the passage. Then a 10-item quiz was given on the computer. After the quiz, the subjects were asked to stop again to judge whether the passage was more difficult than they thought before the quiz, in order to decide if achievement on the quiz had influenced the judgement of the task difficulty. Subjects also were asked if they would like to learn under the same learning aid condition or not. Afterwards, the subjects read the more technical passage "Tsunami." The same procedures were administered again. After the second quiz, subjects compared their own AIME with other people´s and compared the difficulty levels of these two passages.

Results and Discussion

The means and standard deviations of correct responses to the two types of posttest items and the combined scores are presented in Table 1.

Insert Table 1 Here

Although the mean scores on the self-generated group were slightly higher than the other two groups, oneway analysis of variance on the types of test items revealed a nonsignificant effect for: factual items, F(2,27)=1.05, $p < .16$, comprehensive test items, F(2,27)=.61, $p < .25$, and the combined scores, F(2,27)= 1.36, $p < .17$. These results do not support the hypothesis that self-generated underlining group would perform better than the other two groups.

The 2 (learning style) X 3 (treatment) multivariate analysis of variance revealed nonsignificant effects for learning style, F(1,27)=4.27, and treatment F(2,27)=4.19, and learning style and treatment interaction F(2,27)=3.08. These results suggest that ATI effect does not exist between learning style and treatment.

In the optional control group, asking for more help resulted in a worse performance (r=-.41, P < .01). This result may be explained by the "interference" effect (Windfield & Brynes, 1981).

Intercorrelations, means, and standard deviations of the intervening variables are displayed in Table 2.

Insert Table 2 Here

Learning style was not significantly correlated with any of the other variables except the amount of experiences working with computers. The significant negative correlation (r=-.48, p < .01) between learning style and experiences with computer indicated that most of the computer users possessed passive observing (or reflective observation) type of learning style, which is inconsistent with the theory of career development reported by Kolb that computer experts usually scored higher in the active experimentation dimension (1985). The perceived task difficulty is weakly but significantly correlated with the AIME (r=.27, p < .01), and time-on-task (r=.46, p < .01). These results are consistent with the literature which suggested that if the learners perceived the tasks as difficult, they would spend more time on the task and reported that a greater amount of efforts are invested. Finally, the significant correlation between perceived task difficulty and compared AIME (r=.55, p < .01) suggests that when learners perceived a task as difficult, they will have a tendency to think that they have tried harder than other learners in understanding the text.

To investigate further the pattern of correlations among the variables, a multiple regression analysis was computed with reading performance as the criterion variable. The results are presented on Table 3.

Insert Table 3 here

The variables were entered into the regression equation in the fixed order of compared AIME, learning style, time-on-task, reading ability, computer user and the AIME. The results of this analysis, which are presented in Table 3, indicate that compared AIME, learning style, and time-on-task are the best predictors of reading performance.

Summary and Conclusion

In summary, there were three major findings from this study: (1) ATI effect between learning style and treatment does not exist. (2) The hypothesis that intentional learning on the factual items, which were underlined in the program-provided underlining group, would lead to better performance was not supported. (3) Compared AIME is a better predictor for the reading achievement than the AIME. (4) Perceived task difficulty has positive relationship with time and the AIME. That is, when the learners perceived the task as difficult, they spent more time on the task and reported more effort have been invested. (5) In the optional control group, "help" on the underlining does not facilitate the reading performance.

The insignificant results of the study may have caused by the following factors: (1) the sample size was too small to make reliable conclusions. There were only nine subjects in each treatment. In the learning style vs. treatment interaction analysis, subjects in each cell ranged from three to five. (2) The reliability of the test items were not high: Nelson-Denny Reading Test was originally administered as a timed test. In this study, students were given sufficient time to accomplish the text reading. Therefore, the reliability of the test items has decreased from .77 to .45. (3) No delayed retention test was given to the subjects. Thus, the possibility that self-generated learning would lead to better retention was not tested.

There are two suggestions for further study: (1) Provide other learning aids such as summary and adjunct questions, because underlining facilitates only shallow information processing, which will not foster reading comprehension and retention as summary and adjunct questions will. (2) Make the best use of the computer: collect the data on learners' underlining prototypes and compare those with the reading experts. This can help us to understand the quality differences of information encoding process between experts and good vs. poor readers.

Table 1

Mean and Standard Deviation of Correct Responses as a Function of Test Item Type and Treatment

	Treatment					
	Self-Generated		Program-Provided		Optional	
Types of Test Items	M	SD	M	SD	M	SD
Factual items	8.22	1.39	7.56	1.33	7.67	1.41
Comprehensive items	7.44	0.88	7.22	1.64	6.56	0.88
Combined score	15.67	1.94	14.78	2.39	14.22	2.05

Table 2

Intercorrelation Matrix Among the Intervening Variables

Variables	1	2	3	4	5	6	7
1. Learning style		-.30	.06	.37	-.03	-.24	-.48*
2. AIME			.27*	.11	.22	.42	.33
3. PTD				.46*	.55*	-.27	.13
4. Time-on-task					.08	.11	-.07
5. Compared AIME						-.02	.08
6. Reading ability							.11
7. Experience with computers							
MEAN	4.00	7.00	5.89	1205.52	2.33	1.37	1.30
SD	12.60	1.73	1.63	860.76	1.24	0.69	0.54

Note: N=27. * p < .01.

Table 3

Summary of Multiple Regression Analysis With Reading Performance as the Criterion Variable

Variables	F	Standardized B Value	Increase in R^2
1. Compared AIME	6.35	.45	.20*
2. Learning style	5.32	.65	.22*
3. Time-on-task	4.82	.72	.10*
4. Reading ability	3.46	.72	.00
5. Experience with computers	2.67	.72	.00
6. AIME	2.19	.73	.00

Note. N=27. * $p < .01$.

Bibliography

Anderson, R. C., Reynolds, R. E., Schallert, D. L., & Goetz, E. T. (1977). Frameworks for comprehending discourse. American Educational Research Journal, 14, 367-382.

Alessi, S. M., & Trollip, A. R. (1985). Computer-based instruction: Methods and development. Prentice-Hall, Inc., NJ: Englewood Cliffs.

Ausubel, D. P. (1968). Education psychology: A cognitive view. New York: Holt, Rinehart & Winston.

Balajthy, E. (1986). Microcomputers in reading and language arts. Prentice-Hall, Inc., NJ: Englewood Cliffs.

Borrow, D. G., & Collins, A. (1975). Representation and Understanding: Studies in cognitive science. New York: Academic Press.

Brown A. L., & Day, J. D. (1983). Macrorules for Summarizing Texts: The Development of Expertise. Journal of Verbal Learning and Verbal Behavior, 22, 1-14.

Brozo, W, G., Schmelzer, R. V., & Andrews, D. A. (1984). Setting the Pace, Bell & Howell Co., Columbus, Ohio.

Cashen, V. M., & Leicht, K. L. (1970). Role of the isolation effect in a formal educational setting. Journal of Educational Psychology, 61, 484-486.

Craik, F. I. M., & Lockheart, R. S. (1972). Levels of processing: A framework for memory research. Journal of Verbal Learning and Verbal Behavior, 11, 671-684.

Coles, P., & Foster, J. (1975). Typographic cuing as an aid to learning from typewritten text. Programmed Learning and Educational Technology, 12(2), 102-108.

Cronbach, L. J., & Snow, R. E. (1977). Aptitudes and instructional methods: A handbook for research on interactions. New York: Irvington.

Crono, L., & Mandinach, E. B. (1983). The role of cognitive engagement in classroom learning and motivation. Educational Psychologist, 18(2), 88-108.

Dosher, B. A., & Russo, J. E.. (1976). Memory for internally generated stimuli. Journal of Experimental Psychology: Human

Learning and Memory, 2(6), 633-640.

Gay, G. (1986). Interaction of learner control and prior understanding in computer-assisted video instruction. Journal of Educational Psychology, 78(3), 225-227.

Glynn, S. M., & DiVesta, F. (1979). Control of prose processing via instructional and typographical cues. Journal of Educational Psychology, 71(5), 494-603.

Heppner, F. H., Anderson, J. G. T., Farstrup, A. E., & Nelson, H. W. (1985). Reading performance on a standardized test is better from print than from computer display. Journal of Reading. 321 -325.

Hyde, T. S., & Jenkins, J. J. (1969). Differential effects of incidental tasks on the organization of recall of a list of highly associated words. Journal of Experimental Psychology, 82, 472-481.

Keefe, J. W. (1979). (Eds.) Student Learning Styles: Diagnosing and Prescribing Programs, Reston, Va.: National Association of Secondary School Principals.

Kintsch, W., & VanDijk, T. A. (1978). Toward a model of text comprehension and production. Psychological Review, 85(5), 363 -394.

Kolb, D. A. (1981). Disciplinary inquiry norms and student learning styles: Diverse pathways for growth. The Modern American College, Chickering A. (Eds.), San Francisco: Jossey -Bass.

Lepper, M. R. (1983). Extrinsic reward and intrinsic motivation: Implications for the classroom. In J. M. Levine, & M. C. Wand (Eds.) Teacher and student perceptions: Implications for learning (pp. 281-317). Hillsdale, NJ: Erlbaum.

Mayer, R. E. (1975). Information processing variables in learning to solve problems. Review of Education Research, 45, 525-541.

Mayer, R. E. (1984). Aids to text comprehension. Educational Psychologist, 19, 30-42.

Merrill, P. F. (1982). Displaying text on microcomputers. In Jonassen, D. H. (Eds.) The technology of text: Principles for structuring, designing, and displaying text.Educational Technology Publication, NJ: Englewood Cliffs.

Muter, P., Latremouille, S. A., & Treurniet, W. C. (1982). Extended reading of continuous text on television screens. Human Factors, 24(5), 501-508.

Nelson-Denny Reading Test (1960). Chicago, Ill: Riverside Publishing Co.

Pepper, R. J., & Mayer, R. E. (1985). Generative effects on note -taking during science lectures. Journal of Educational Psychology, 78(1), 34-38.

Pittman, T. S., Boggiano, A. K., & Ruble, D. N. (1983). Intrinsic and extrinsic motivational orientations: Limiting conditions on the undermining and enhancing effects of reward on intrinsic motivation. In J. M. Levine, & M. C. Wand (Eds.) Teacher and student perceptions: Implications for teaching. Hillsdale, NJ: Erlbaum.

Rosch, G. D. (1980). Videotext and the publishing industry. Vital Speeches, 47, 98-100.

Rothkoph, E. Z. (1970). The concept of mathematics as instrumental learning activities. Instructional Science, 3, 51 -74.

Salomon, G. (1984). Television is "easy" and print is "tough": The differential investment of mental effort in learning as a function of perceptions and attributions. Journal of Educational Psychology, 74(4), 647-658.

Snow, R. E. (1980). Aptitude, learner control, and adaptive instruction. Educational Psychologist, 15(3), 151-158.

Wittrock, M. C. (1974). Learning as a generative process. Educational Psychologist, 11, 87-95.

Research on Learning from Interactive Videodiscs: A Review of the Literature and Suggestions for Future Research Activities

Marcia B. Cushall

Francis A. Harvey

Andrew J. Brovey

College of Education
Lehigh University
Bethlehem, PA 18015

Research on Learning from Interactive Videodiscs: A Review of the Literature and Suggestions for Future Research Activities

Introduction

Microcomputer-controlled interactive videodiscs provide a powerful and flexible instructional medium. Development of effective applications of this medium must be guided by a rigorous research into the nature of the medium and the forms of presentation most appropriate for particular subject matter, learners, and educational settings.

Two major themes emerge from a review and analysis of research on learning from interactive video: (1) interactive video as an instructional delivery system; and (2) research on principles of learning using interactive video as the instructional medium of delivery. This paper will discuss each of these themes, then present suggestions for future areas of research. The bibliography contains a listing of all articles that were reviewed. Several of these articles will be cited as specific examples of the major themes.

Research on interactive video as an instructional delivery system

1. Is interactive video as effective or more effective than other instructional delivery systems?

Most research involving interactive video has addressed this question. Representative studies include the U. S. Army Signal Center studies (Ketner, 1982), which found no advantage to using videodisc simulations over actual equipment to train satellite ground station technicians, and the WICAT introductory college Biology study (Bunderson, Olsen, & Baillio, 1981), which found significant knowledge gains and time savings compared to traditional lecture methods.

2. Is the use of interactive video as an instructional delivery system more time and/or cost effective than other media?

Research on this topic by the military and the WICAT study (Bunderson et. al., 1981) previously mentioned generally report that interactive videodisc-based instruction achieved the same or better results in less time than other methods, and thus was cost-effective.

3. Are the attitudes of the instructor and/or learner affected by the use of interactive video as the instructional delivery system?

Attitude surveys, usually conducted in conjunction with other types of effectiveness measurements, generally report significantly more positive attitudes toward learning from interactive video than from other methods by both students and instructors. Attitude gains are particularly striking with younger learners.

Research on principles of learning applied to interactive video

Few studies investigating principles of learning using interactive video as the instructional medium have been reported. Researchers investigated the nature of feedback, types of interaction, group versus individual viewing, and learner control versus program control, often as part of larger studies comparing interactive video to other media of instruction. The Open University study of control of learning (Laurillard, 1984), which found that students watched video presentations for shorter periods and interrupted more frequently when offered a menu of options at the end of each instructional segment, is typical.

Limitations of current studies

Most of the research literature on interactive video addresses the question of interactive video as an effective instructional delivery system. Results of this research have limited generalizability, and the results are difficult to replicate. A major limitation preventing replication and the development of more general understanding of interactive video is the large number of variables, such as different subject matter, instructional strategy, prior knowledge and experience of the learner, which are difficult to control for.

An additional limitation is that many of the studies used videotape as the interactive medium. Many educators feel that access time of videotape is too slow to make interactivity effective, although we were not able to identify any studies which specifically addressed this question.

A proposed agenda for further research

1. Codifying the attributes of interactive video

In interactive video, the whole is not only more than the sum of its parts but is in fact a completely new and unique delivery system. The "grammar" of interactive video, that is, the ways in which interactive video materials can be organized and manipulated, should be more completely specified. The work of Gavriel Salomon (1983) on codifying the grammar of instructional television would serve as an appropriate model for this undertaking.

Further research is needed on questions such as:

- What learning tasks best lend themselves to this type of delivery?
- Should the unit be learner controlled, instructor controlled, or program controlled?
- If a unit is learner controlled, how much freedom should be given to the learner?
- What types of questioning techniques are appropriate?
- What types of information retrieval systems should be used?
- How does use of a specific characteristic of text, graphics, audio, or video (for example: pacing of video, animation versus live action, graphics overlay, audio over still frame) influence the effectiveness of other characteristics with which it is used? How does it's use influence the effectiveness of the overall interactive video presentation?
- What is the appropriate balance between computer and video components?

2. Examining research on other media

In codifying the attributes of interactive video, researchers should recognize that interactive video, although new and unique, shares many features with instructional film and instructional television on the one hand, and with computer-based instruction on the other. A detailed examination of the research literature on learning from other visual media, particularly film and (non-interactive) instructional television, should be carried out, in order to identify those features of video presentations (e.g. zooming, inserts, splitscreen, closeups) which are most directly related to increased learning when used in non-interactive video or film. Studies of the use of these same features in the context of interactive videodisc should then be carried out, in order to validate their effectiveness in an interactive environment. A similar examination of the research literature on computer-based instruction should be conducted.

3. Investigating the instructional environment

More attention should be paid to the instructional environment in which interactive videodisc-based learning takes place. Very different results may be obtained from the same videodisc materials in different settings. Aspects of the instructional environment which should be investigated include:

- What instructor styles are most appropriate for particular subject matter or particular learners?

- What is the optimal viewing audience size -- individual, small group, large group? Does it vary with content and instructional strategy?
- What is the optimal design of an interactive video laboratory.?
- What is the effect on learning of the presence or the absence of auxiliary materials ? How are auxiliary materials used in the environment?
- What differences in learning occur between a group in which peer interaction is encouraged and a group in which peer interaction is discouraged?

General considerations in planning future research efforts

We now present two general suggestions for making future research activities more useful and more efficient.

1. Focusing on generalizable results

Those attributes of effective interactive videodisc presentations which are generalizeable, not subject-specific or presentation-specific, need to be identified. This can be achieved through replication of selected studies using videodisc materials dealing with different subject matter, or by using the same materials in different settings.

2. Extending the role of formative evaluation

Formative research should go hand in hand with production of videodisc materials. Such research should be conducted and reported quickly enough so that the results can guide further production. Producers should include additional post-production (for re-shooting materials or additional editing) funds in budgets, or increase production budgets so that several approaches to the same material can be produced. All alternative versions could then be mastered on an inexpensive check disc and evaluated. The relatively slight increase in production costs could result in a much more effective final product.

Summary and Conclusions

Interactive video holds great promise as an instructional tool. Systematic research is required, however, if interactive video is to achieve its full potential and contribute to improved teaching and learning. It is hoped that this paper will contribute to an understanding of current research on videodisc-based learning and provide a context for determining a future research agenda.

Bibliography

Balson, P., Manning, D., Ebner, D., & Brooks, F. (1984). Instructor-controlled versus student-controlled training in a videodisc-based paramedical program. Journal of Educational Technology Systems, 13(2), 123-130.

Boen, L. (1983). Educational technology research: Teaching with an interactive video-computer system. Educational Technology, 23(3), 42-43.

Browning, P., White, W., Nave, G., & Barkin, P. (1985). The effectiveness of interactive video for teaching handicapped learners: Preliminary findings. Paper supported by a grant from the National Institute of Handicapped Research.

Browning, P., White, W., Barkin, P., & Nave, G. (1985). Interactive video in the special classroom: A pilot study. The Computing Teacher, 13(4), 36-38.

Bunderson, C., Olsen, J., & Baillio, B. (1981). Final Report: Proof-of-concept demonstration and comparative evaluation of a prototype intelligent videodisc system. ERIC ED 228 989.

Carr, C., & Carr, E. (1983). Programs for an intelligent optical video disc learning system. Herkimer, NY: Herkimer Boces Planetarium.

Carter, J., Browning, P., Nave, G., & White, W. (1985). Interactive video as a learning medium for mentally handicapped adolescents. Journal of Special Education Technology, 7(1), 12-20.

Dalton, D. (1986). How effective is interactive video in improving performance and attitude? Educational Technology, 26(1), 27-29.

Dalton, D. (1986). The efficacy of computer-assisted video instruction on rule learning and attitudes. Journal of Computer-Based Instruction, 13, 122-125.

Dalton, D., & Hannafin, M. (1986). The effects of video-only, CAI only, and interactive video instructional systems on learner performance and attitude: An exploratory study. Proceedings of Selected Research Paper Presentations at the 1986 Annual Convention of the Association for Educational Communications and Technology, pp153-165.

Daynes, R., Brown, R., & Newman, D. (1981). Field test evaluation of teaching with videodiscs. Educational & Industrial Television, March, 54-57.

Ebner, D., Manning, D., Brooks, F., Mahoney, J., Lippert, H., & Balson, P. (1984). Videodiscs can improve instructional efficiency. Instructional Innovator, 29(6), 26-28.

Field test results of Nebraska-produced videodiscs, (1981). Project Paper No. 5. Lincoln, NE: University of Nebraska-Lincoln.

Fuller, R. (1985). From the Dragon's Lair to the Tacoma Bridge. Videodisc and Optical Disk, 5(1), 37-51.

Gay, G. (1986). Interaction of learner control and prior understanding in computer-assisted video instruction. Journal of Educational Psychology, 78, 225-227.

Glenn, A., Kozen, N., & Pollak R. (1984). Teaching ecomonics: Research findings from a microcomputer/videodisc project. Educational Technology, 24(3), 30-32.

Gratz, E., & Reeve, R. (1983). Individualizing instruction through interactive video. ERIC ED 234 750.

Hannafin, M. (1985). Empirical issues in the study of computer-assisted interactive video. Educational Communication and Technology Journal, 33, 235-247.

Hannafin, M., Phillips, T., & Tripp, S. (1986). The effects of orienting, processing, and practicing activities on learning from interactive video. Journal of Computer-Based Instruction, 13, 134-139.

Ho, C., Savenye, W., & Haas, N. (1986). The effects of orienting objectives and review on learning from interactive video. Journal of Computer-Based Instruction, 13, 126-129.

Hofmeister, A. (1986). The development and validation of an instructional videodisc program-preliminary draft. Logan, UT: Utah State University.

Holmgren, J., Dyer, F., Hilligoss, R., & Heller, F. (1979). The effectiveness of army training extension course lessons on videodisc. Journal of Educational Technology Systems, 8(3), 263-274.

Kearsley, G. & Frost, J. (1985). Design factors for successful videodisc-based instruction. Educational Technology, 25(3), 7-13.

Ketner, W. (1982). Videodisc interactive two dimensional equipment training. Proceedings of the Fourth Annual Conference on Video Learning Systems. Videodisc for Military Training and Simulation. Warrenton, Virginia: Society for Applied Learning Technology, pp 18-20.

Kimberlin, D. (1982). The U.S. Army Air Defense School distributed instructional system project evaluation. Proceedings of the Fourth Annual Conference on Video Learning Systems. Videodisc for Military Training and Simulation. Warrenton, Virginia: Society for Applied Learning Technology, pp 21-23.

Kirchner, G., Martyn, D., & Johnson, C. (1983). Simon Fraser University videodisc project: Part two: Field testing an experimental videodisc with elementary school children. Videodisc, Videotext, 3(1), 45-58.

Laurillard, D. (1984). Interactive video and the control of learning. Educational Technology, 24(6), 7-15.

Laurillard, D. (1985). The teddy bears' disc. Media in Education and Development, 18(1), 37-41.

Propp, G., Nugent, G., Stone, C., & Nugent, R. (1980). Videodisc: An instructional tool for the hearing impaired. ERIC ED 200 227.

Russell, A., Staskun, M., & Mitchell, B. (1985). The use and evaluation of videodiscs in the chemistry laboratory. Journal of Chemical Education, 62(5), 420-422.

Salomon, G. (1983). Television watching and mental effort: A social psychological view. In J. Bryant and D. Anderson (Eds.), Children's understanding of television. N.Y.: Academic Press, pp 181-198.

Schroeder, J. (1982). U.S. Army VISTA evaluation results. Proceedings of the Fourth Annual Conference on Video Learning Systems. Videodisc for Military Training and Simulation. Warrenton, Virginia: Society for Applied Learning Technology, pp 1-3.

Schrupp, D., Bush, M., & Mueller, G. (1983). Klavier im haus - an interactive experiment in foreign language instruction. CALICO Journal, 1(2), 17-21.

Smith, S., Jones, L., & Waugh, M. (1986). Production and evaluation of interactive videodisc lessons in laboratory instruction. Journal of Computer-Based Instruction, 13, 117-121.

Spencer, J. (1983). IVIS benchmark study. Report presented to ESD&P Research & Development Group at DEC.

Some Advantages and Disadvantages of Narrow-Cast Instructional Television: One Instructor's Experience

David W. Dalton
Indiana University

Abstract

This presentation describes the author's experiences in teaching a narrow-cast instructional development course. Among the disadvantages of the experience were the logistics of coordinating the instructional activities between two campuses, additional preparation time requirments, diminishedstudent-teacherinteractions, and negative learner attitudes. Advantages included smoother, more effective class sessions, more effective text and graphic visuals, decreased cost and increased course offerings, a more diverse group of learners, and the opportunity to demonstrate the use of alternative instructional delivery strategies to novice instructional developers.

Introduction

During my second semester at Indiana University, I was approached by my department chair and asked if I would like to narrow-cast the sessions of my introductory Instructional Development course to the "core campus" of IU. Here, the "core campus" can mean many things, depending on how and when the concept is applied. Generally, the core campuses of Indiana University include Indiana University Purdue University Indianapolis (IUPUI) and the Bloomington campus.

At Bloomington, the Instructional Systems Technology department has made a commitment to teaching various programs on the IUPUI campus, but due to factors including commute time and distance and the lack of qualified instructors in Indianapolis, we often have difficulty in meeting those commitments. In short, the Bloomington faculty can not be in two places at one time.

Enter the Indiana Higher Education Television System or IHETS. IHETS is a narrow-cast instructional television system that allows us to be in several places at once through the magic of television. On the Bloomington campus, instructional television programming is accomplished through the Radio and Television department, and cable-cast to the receiving classrooms at other campuses.

My first reaction to such a proposition was admitedly a bit egocentric. I felt as if I had suddenly been made a "star." So, despite some warnings from a colleague who had been televising such courses in the past, I agreed and plunged headlong into awaiting fame.

Some Disadvantages

First, the bad news. Needless to say, my naivté shone through almost immediately. My first task was to tour the studio where the taping was to occur. To this day, I must say that I am still somewhat awed by television technology. The studio used for this type of ITV course is shared by WTIU, the local public television station. Although not grand praise, these facilities are among the finest of their kind in the State.

The lights, cameras, and action abounding before me convinced me that I was indeed going to be a "star." My director, John Winninger, struggled hard to convince me that it really was not that big a deal, but never the less, I was awestruck. Together, we decided that we would narrow-cast live so that the audience at IUPUI could ask any questions as they arose. We also decided to include the entire Bloomington class as the studio audience and placed them on a lighted stage.

The first major disadvantge that we encountered seems, in hindsight, to be somewhat obvious. From the first night the studio lights and the TV appartus seemed to stiffle the questions of most the students in the "live" audience. They seemed to feel as if their questions would make the production suffer. Despite many attempts, it was exceedingly difficult to sustain class discussions or encourage questionning. To rectify this situation, we moved the audience off-stage, and placed microphones overhead to pick-up their questions. This change not only improved the amounts of discussion, but also improved my ability to engage in meaningful eye contact with the studio group. However, the frequency of questions still was far less than a "conventional" classroom environment and I noted an overall dimished sense of rapport with the studio group as the result.

On the subject of questions: because of budget constraints, the direct telecommunications link with the IUPUI audience was removed. Instead, they had to pick-up a device similiar to a standard telephone which would actually place what amounted to a long-distance phone call for each question. Unfortuanetly, this calling mechanism required eight seconds to accomplish. Now, eight seconds may not seem like a great deal of time, but it always seemed to be a "just missed" situation. I'd call for questions and wait one or two seconds too few, or they would call and catch me as I began a new topic, one or two seconds too late.

Of course there were minor inconveniences encountered all the time. For example, the need to dress and adopt a general demeanor that was more formal than my usual style was a bit of a nuisance at first, as was wearing the microphone and earpiece.

But the major problems surrounding this experience related to handling the logistics with the IUPUI group. Despite assurances to the contrary, there was never a reliable contact person in Indianapolis that would handle such seemingly trivial matters as proctoring and collecting exams, distributing class materials, collecting assignments, etc. For example, when it came time for the final exam, there was simply no one willing to pass-out or proctor the exam and the students sat for two hours waiting for someone to show-up with an explanation for why their study time had been so ill-spent.

One additional problem that caused difficulty throughout the semester was a calendar conflict. The official IUPUI semester began and ended 10 days before that of the Bloomington campus and the spring recess for the two campuses fell during different weeks. The result was a condensing of the number of sessions and an occasional tape-delay for one or more of the audiences.

Some Advantages of ITV

Now for the good news. In many ways, this ITV experience proved beneficial personally and professionally. Although I've been teaching for many years, I've never been forced to prepare as carefully and thoughtfully as when the course was televised. Although my first reaction to the amount of planning required was that it would constrain my creativity and stiffle the spontaneity, not to mention detract from my other commitments, I found that the opposite was often the case. The more I carefully planned the presentations, the more comfortable I became in digressing and enlivening the material. By knowing what was to come next, I was able to relax and not worry about filling time or "flying by the seat of my pants."

From the ID perspective, this experience once again demonstrated the utility of carefully designed and developed instruction. I not only felt more comfortable with the content, but I also felt more effective as an instructor.

There were also advantages from a message design perspective. Instead of displaying transparencies or simply "talking through" important points, I was able to use computer-generated text to highlight important points, show the learners examples, display the lesson outline, etc. In addition, the visuals I developed were displayed with a close-up camera and a "chroma key" that allowed me to "zoom in" on each individual section of the graphic and drop back for a more hollistic look. The manipulations of text and visual material were far more sophisticated than what I was ordinarily capable of accomplishing with a simple overhead projector or chalkboard.

Another notable advantage of this system was related to the taping itself. At the conclusion of each show, I received a standard VHS-format cassette which I could then check-out to students who had either missed the class session or who needed additional review. As a footnote, in this particular class, approximately 50 percent of the learners are not native English language speakers and there is a significant range in their respective language abilities. These tapes provided many of these students with a review opportunity not usually possible. However, there were lingering delivery problems, principally due to the lack of public access viewing stations, that prevented this system from being used to its fullest.

Another advantage related to the video equipment was the capability of taping sessions ahead of time. On one occasion, I needed to attend a conference during the time when the class was held. Here, I simply arranged to tape the session a week earlier and narrow-cast it during the regularly scheduled time slot.

Of course there were larger benefits than the technological miracles offered by the video equipment *per se*. First, the course experience was somewhat enriched through the addition of the IUPUI group. These learners were represenative of a population of learners that are generally somewhat older and more focused in their motives than the Bloomington audience. Yet, the Bloomington crowd represents a very diverse and culturally heterogeneous mixture of learners. The two populations seem to compliment each other well.

The benefits to the University seem somewhat obvious. Because an instructor can be several places at once, the costs, especially those incurred by the remote campuses, are low, limited almost entirely to very small administrative costs. In addition, the learners on the remote campuses benefit from courses that, because of small enrollments, high costs, or lack of qualified faculty, would otherwise not be offered. Because of these factors, the attitudes of the IUPUI learners was exteremely positive, despite many logistical problems.

Finally, the most salient advantage from my perspective was the opportunity to "practice what we preach" to a greater extent. As an instructional developer, it was far more credible for me to offer such a course through a more deliberate, mediated approach than the conventional classroom. This is not to say that this course was necessarily representative of the optimal ID environment; certainly, it was not. However, in a larger sense, the learners in this course were exposed to some media and design options that they would ordinarily not see.

The Balance Sheet

Would I do it again? Probably. However, the most frustrating problem and the reason why I may be much less eager to undertake the instructional television experience again in the future is the attitude displayed by the local group. With few exceptions, these learners responded with the attitude that this technology, no matter how beneficial it may be to learning here and throughout the system, somehow cheated them out of the best possible learning environment because of its "staged" nature. Instead of being willing to experiment with a new type of learning situation, many seemed to feel compelled to demand the security and comfort of the conventional classroom.

Among all the lessons that I learned from this experience, one far out-shone the others in my own understanding of the field of instructional development: we as professionals must advocate strongly for pedagogical change, or instructional interventions, no matter how ultimately beneficial we may believe they are, will continued to be viewed merely as new "teaching toys;" here for today, but gone tommorrow. In short, before we can indeed practice what we preach, we must actively sell the better mousetrap.

The Effects of Individual and Team Learning on Performance During Computer-Assisted Instruction

David W. Dalton
Indiana University

Abstract

There is considerable evidence to suggest that CAI is an effective instructional delivery system in many situations. However, the manner in which learners interact with each other is often overlooked in CAI research and in the devlopment of CAI lessons. This study compared the performance and attitudes towards instruction of learners working individually with learners working in two-member teams on a sex education CAI lesson. On two measures of outcome performance, learners working together significantly outscored those working individually. However, there were no significant differences observed on the attitude towards instruction measure.

Background

In the past decade, research has shown that computer-based instructional programs have been effective in improving learner performance and attitudes towards instruction.

For example, Kulik, Bangert, and Williams (1983) suggest that the typical computer-based instructional program produced a gain of .5 standard deviations over similar "conventional" instructional programs. In a recent follow-up analysis, Kulik, Kulik, and Bangert-Drowns (1985) note similar results when computer-assisted instruction (CAI) programs are used with elementary learners.

One of the main assumed benefits of CAI as an instructional delievery system lies in its ability to provide individualized instruction through branching options contingent on individual learner progress. The consistent nature and quality of the differentiated feedback and reinforcement found in many well-designed CAI lessons has also been credited with performance and attitude improvement (Clement, 1981).

Since much of the assumed benefit of CAI is often centered around its facility for the delivery of individualized instruction, much of the research on CAI to date has focused on traditional, one learner per machine interactions. However, research in conventional instruction suggests that cooperative, or team learning experiences can often produce improvements in learner performance and attutude.

In addition, it has been suggested that cooperative learning schemes used with appropriately designed CAI assist in the development of social skills, creative thinking, and overall performance. However, whether or not such cooperative learning schemes do indeed improve learner attitude and performance has not been conclusively demonstrated and more research is required.

This paper reports on the findings from a study that compared the performance and attitudes towards instruction of learners working in pairs with learners working individually.

Methods

Subjects

The subjects chosen for partcipation in this study were 60 eighth grade learners selected from two sections of an eighth grade health class. The sample consisted of approximately equal numbers of males and females and was composed primarily of Anglo students, with some minority learners.

Materials

The basic instruction for this study consisted of a 30 minute lesson on the anatomy and physiology of the human male and female reproductive and urinary systems. The lesson consisted of two major sections, one for each gender. Each section contained instruction on the major organs of the reproductive system and their functions in the reproductive cycle.

Each lesson segment began by describing the size, shape and location of the organ in tutorial form, followed by a computer-generated graphic depicting the organ in the body. Then a brief explanation of the organ's function was given, again in tutorial form. At the end of each such segment, the learners were asked to recall the name of the organ and its function. Two treatment groups were employed as follows.

Individual instruction. In this treatment, learners were assigned to a computer terminal and instructed on the operation of the computer hardware and software. They were then told to complete the lesson individually and report to the teacher when finished.

Team instruction. In this treatment, each learner was randomly assigned a partner with whom to complete the lesson. The learners were then given the operating instruction as in the individual instruction treatment above. The partnerships were then told to complete the lesson by "working together" at the keyboard. At the end of the first half of the instruction, the learners were told to switch positions so that each learner would be entering the team's responses for half of the lesson time.

Dependent Measures

After the completion of their respective treatments, all learners were given two print-based posttests on the anatomy of the human male and female reproductive and urinary systems, as well as an attitude survey designed to assess the learners' attitudes towards the instruction.

Verbal information posttest. The first of these measures consisted of 36 multiple choice items covering both the names and functions of the organs of the reproductive systems. Split-half reliability of this measure was found to be .90 using data from this study.

Visual recall posttest. This test contained 12 items that asked the learner to label line drawings of the reproductive systems. Reliability of this measure was found to be .85 using split-half data obtained during the study.

Attitude survey. In addition to the achievement measures described above, the learners were also given an annonymous print-based twenty-item Likert-type survey designed to assess their attitudes towards the instruction. The split-half reliability coefficient of this instrument was found to be .86.

Procedures

Learners were randomly assigned to their respective treatments where they completed the instruction. Immediately following the lesson, the learners were given the achievement measures and the attitude survey previously described.

Experimental Design Data Analysis

This experiment utilized a completely crossed 2 x 2 Treatment-by-Sex factorial design, featuring two levels each of treatment (team learning and individual learning) and sex (male and female).

Scores on the performance posttests were analyzed through fixed-effects ANCOVA procedures, using sixth grade Comprehensive Test of Basic Skills (CTBS) total scores as the covariate. Attitude data from this study was analyzed with fixed-effects ANOVA procedures.

Results

The results for the verbal information posttest, visual recall posttest, and attitude survey are contained in Table 1. The adjusted means of the individual instruction and the team learning treatment groups were 62.93% and 86.07%, respectively, on the verbal information posttest. These means were significantly different ($p < .001$).

The adjusted means of the individual instruction and team learning group were 55.17% and 74.17%, respectively, for the visual recall posttest. These means were also significantly different (p < .001).

The means of the individual instruction and team learning group were 64.48% and 66.77%, respectively, for the atttude survey. These means were not statistically different (p > .05).

Discussion

The most important result from this study was that the team learning treatment scored significantly greater than the individual learning group on both measures of performance. In fact, the effect size of the team learning approach was 1.13 standard deviations for the verbal information posttest and 1.31 standard deviations for the verbal recall posttest and was consistent across both sexes.

This result is easy to interpret when coupled with observations made of the learners as they progressed through their lessons. The pattern of behavior that seemed most typical involved one learner assuming the role of tutor while the other learner became the tutee. In this way, many of the benefits of the Programmed Tutoring system were realized. Specifically, the tutor gained new understanding of the material by verbalizing the materials for his/her partner, while the tutee benefited by his/her peer's explanations.

In addition, there seemed to be an added comfort that came from working together on content that seemed to embarass students working individually. In fact, this comradery was present in both genders.

However, in two of the 15 partnerships, the tutoring relationship degenerated into a competitive, rather than cooperative relationship. In both these cases, the tutor assumed an authoritative role and the tutee rapidly became resentful of his/her peer's demeanor.

No significant differences were yielded on the attitude survey. This result may be attributable to the fact that both treatment groups reacted quite positively to their respective treatments since both treatments represented novel instructional methods.

In summary, the results of this study support research that suggests that tutoring in general, and especially tutoring coupled with CAI, can be an effective mode of instruction, especially for young learners.

However, future research should be conducted on methods in which the CAI lesson itself can maximize the peer tutoring that results from this type of team learning. Perhaps such research efforts may find design approaches which not only maximize learner performance through cooperation, but also minimize the opportunities for unconstructive competition among learning partners.

References

Clement, F. (1981). Affective considerations in computer-based education. *Educational Technology, 21(4),* 28-32.

Kulik, J., Bangert, R., and Williams, G. (1983). Effects of computer-based teaching on secondary school students. *Journal of Educational Psychology, 75(1),* 19-26.

Kulik, C., Kulik, J., and Bangert-Drowns, R. (1985). The importance of outcomes: A reply to Clark. *Journal of Educational Computing Research, 4(2),* 381-87.

Table 1. Mean percent scores for the verbal information, visual recall, and attitude survey.

Treatment	Verbal Info Posttest	Visual Recall Posttest	Attitude Survey
Individual			
male (n = 14)	62.50%	53.94%	65.71%
female (n = 16)	63.32%	56.28%	63.33%
TOTAL (n = 29)	62.93%	55.17%	64.48%
Team Learning			
male (n = 15)	82.61%	73.33%	62.33%
female (n = 16)	89.28%	75.00%	70.94%
TOTAL (n = 31)	86.07%	74.17%	66.77%

APTITUDE-TREATMENT INTERACTION RESEARCH REVISITED

by

Marcy P. Driscoll

Florida State University

Paper presented at the 1987 Annual Meeting of the
Association for Educational Communications and Technology

Atlanta, GA
February, 1987

APTITUDE-TREATMENT INTERACTION RESEARCH REVISITED

Introduction

While most of us instructional designers and theorists would attest to the importance of designing instruction to meet individual student needs, we have been criticized for our failure to do it effectively. This is not to say we pay no heed to individual student needs. We are quite good at identifying prerequisite skills to a desired learning outcome and which of these skills individual students possess. Armed with this knowledge, we may prescribe at what point in the instructional sequence any given student should begin.

Instructional designers have also paid attention to adaptive learning sequences in the sense that students are individually branched to new instruction based on their current performance. When these two features are coupled with the opportunity for students to proceed at their own pace, the result appears to be individualized instruction, instruction based on individual student learning needs. So, what's the beef? A careful look at these instructional packages will reveal that although the sequence of content may be sensitive to individual differences, the learning process is virtually the same for all students. Little or no provision is made for varying student interests, learning strategies, learning styles, and the like.

Part of the reason for this situation, it can be argued, stems from the unfulfilled promise of aptitude-treatment interaction (ATI) research. This research seeks to establish relations between learner characteristics and instructional treatments that will permit instructional designers to specify that one mode of instruction is ideal for a group of learners with one set of characteristics while an alternate method is optimal for a group of learners with different characteristics. Unfortunately, this research has yielded and continues to yield little in the way of clearcut, replicable results. Moreover, one regularly sees reported in the literature ATI studies in which the hypothesized interaction was of secondary interest and unsupported by theory or logic.

The intent of this paper is to re-examine ATI research, to reflect upon and question the assumptions we have been making in conducting this research, and to summarize some recent, more promising approaches to this research that may better serve us in the future. While the focus of the paper is on research, a related question concerns how research should inform practice. Implied in the opening remarks is a belief that adapting instruction to such individual learner characteristics as interest and cognitive style is a good thing to do. This belief will also be re-examined in the closing comments of the paper.

The Promises of the Past

The roots of ATI research may be traced to a book edited by Gagne and published in 1967 in which Cronbach and others proposed a theoretical rationale for such research and summarized some basic and applied research pertaining to it. Aptitudes were considered to include any characteristic of the learner that increases or impairs his or her probability of success in a given instructional treatment. Examples of some of these personological variables most commonly investigated include general intelligence, anxiety, achievement need, and others. Treatments referred to any systematic variation in the pace or style of instruction that might be expected to interact with the learner variable of interest. And an aptitude-treatment interaction (ATI) was defined as the interaction between individual differences among student aptitudes and the effects of various instructional treatments.

It was, and still is, intuitively appealing to think that some students could be expected to perform better under one set of instructional conditions while others required a different set for optimal performance. All that remained was to delineate those interactions; what instructional treatments were best for what types of learner characteristics?

There ensued some 10 years of research before the question was raised as to why the reasonable assumptions of ATI were not generating the anticipated empirical support. Many ATI studies resulted in no significant differences between groups; others which reported interactions proved to be difficult, and sometimes impossible, to replicate under similar conditions.

Reviewers have offered a variety of explanations, often in the form of criticisms, to account for this lack of consistent findings. According to Jonassen (1982), for example, ATI research has been largely atheoretical. Empirically conceived without a supportive conceptual base, many studies have resulted in a shotgun approach to identifying learner variables and instructional treatments. Tobias (1976) pointed out a problem with regard to researchers' conceptions of "abilities" and "aptitudes." There is not only lack of agreement as to what a given aptitude means, there is inconsistency in the way investigators have chosen to measure it. This being the case, it is hardly surprising that studies have produced conflicting results.

Other reviewers have noted problems with adequately defining instructional methods being employed as treatments (Tobias, 1981; Jonassen, 1982) and with generalizing laboratory based studies to classroom contexts (Cronbach, 1975; Jonassen, 1982). Instructional treatments, for example, have more often been characterized by such labels as "conventional" vs. "innovative," or "permissive" vs. "directive," than they were defined by what was actually varied across groups that could be expected to influence student processing differentially. The generalizability problem is potentially more serious. Learning may be so context-specific as to preclude the possibility of a general theory of aptitude-treatment interactions. Both Cronbach (1975) and Snow (1977) suggest that local instructional theories dealing with small segments of the curriculum would be a more realistic goal.

The Patterns of the Present

Perhaps in response to the problems identified in early ATI research, at least two developments have emerged in more recent studies. The first is an increased recognition of the role of prior knowledge as an aptitude variable. According to Tobias (1976), a consistent finding of ATI studies was that students' familiarity with the subject matter being taught is important. The higher students' familiarity with the material, the less they needed various types of instructional support, and this was true regardless of any other intervening personological variables.

This result clearly accords with recommendations deriving from current instructional theory. "When educational programs are designed to be adaptive to individual differences, assessing the kind and extent of prior knowledge of students is the most important step to take at the beginning of each new unit of instruction" (Gagne, 1985, pp. 257-258). In practice, this could suggest the development of short vs. elaborated lessons to match the learners' levels of prior knowledge, with the elaborated lessons containing more of the "events of instruction" (Gagne, 1985) to support learning. The more experienced, independent learner, in other words, "will have learned to supply most or all of these supporting events on their own initiative" (Gagne, 1985, p. 256).

The question of what one should actually include in instruction leads to the second, important development in recent ATI research. Investigators are more precisely defining their instructional treatments, with attention to presumed effects on student information processing, than was true in the past. Berliner (1983), for example, developed a taxonomy of "activity structures" to promote investigation of what goes on in elementary school classrooms. McCombs and McDaniel (1983) link instructional strategies with cognitive and affective learning strategies of students to suggest variations in lesson parameters. Others define variations in methods, media, and strategies to influence processing load (Snow, 1977; Clark, 1982), disparity (Rothkopf, 1981), or macro-processes (Tobias, 1982).

Grounding treatment variations in cognitive information processing theory has also focused attention on the different processing requirements of various types of content. In other words, learning one type of content requires a certain set of mental operations, while learning something different might require a different set of mental operations. This is again consistent with current instructional theory (eg., Gagne, 1985; Merrill, 1983). Jonassen (1982) proposes that content-treatment interactions (CTI), as opposed to aptitude-treatment interactions, provide a heuristic for researchers and designers. He contends that this approach, while perhaps not as attentive to certain kinds of learner differences, is more practical, cost-effective, and likely to be productive in terms of curriculum and product development than the ATI approach.

A Forecast for the Future

There are at least two scenarios we might draw for the future based on the preceding discussion. (And they are not necessarily mutually exclusive.) The first pertains to ATI research specifically and the second to the more general concerns about the implications of such research for instructional design.

It seem certain that further progress in demonstrating reliable aptitude-treatment interactions hinges on our ability to more clearly define what we are studying, both in terms of aptitude and in terms of treatments. With regard to aptitude, for example, it is all too easy to use an available score (such as GPA or SAT) to represent an aptitude (such as general ability) and make an ATI prediction when neither the aptitude nor its measure are perhaps the most appropriate for our purpose. If, in fact, general ability is the aptitude of interest, then a more valid measure should be utilized. On the other hand, it is conceivable that GPA may reliably predict performance in some variety of treatments. In that case, description of what the GPA actually measures might be important, rather than it masquerading as a measure of general ability.

With regard to treatments, we are certainly heading in the right direction when we analyze them in terms of specific instructional events and what processes in students these events are designed to support. Clark (1982), for example, cites a study in which a lecture-recitation method was expected to place lower processing burdens on students than was an inquiry method. The opposite, however, turned out to be true. Why? The lecture-recitation method in actuality left students "on their own," whereas the inquiry method provided detailed guidelines and instructional support.

Finally, it has been noted here as well as elsewhere that ATI researchers should pay greater attention to social and contextual variables that may affect ATIs. Perhaps this along with systematic linking of the capabilities of students with specific features of instruction may yet yield the promised results of ATI research.

This could be the end of the paper. However, I made a promise to re-examine the inherent belief with which this paper was begun, namely, that adapting instruction to individual differences among students, on the basis of ATI research results, is a desirable goal. This belief has already been called into question by Jonassen's (1982) proposal to adopt a CTI approach instead of an ATI approach. A CTI approach emphasizes the processing demands of content to be learned and the implications of those demands for the design of instruction. Then, rather than produce a series of instructional methods to match learner characteristics, Jonassen suggests the "one best method" be progressively modified on the basis of information about learners to make it more uniformly effective. Since this type of approach is, I think it is safe to say, at the core of many instructional design models, perhaps we are being unfairly criticized when the charge is leveled at us that we do not effectively account for individual differences.

Another perspective is offered by Parkhurst and McCombs (1979). They examined the practical implications of adapting instruction to individual differences among learners and concluded, "...for most of us, the time and expense involved in alternative module making is not worth taking unless the existing instructional treatment or module causes large or alarming student failure rates or excessive variations in the criterion variable" (p. 34). They go on to provide a working model for making decisions about whether to employ alternative modules and, further, how one might go about designing, evaluating and implementing them.

In conclusion, perhaps all is not "rotten in the state of

Denmark." Instructional design models already focus attention on the needs of learners, and to a large extent, provide for these needs effectively in well designed instruction. However, not to rest on our laurels, ATI research is improving and may yet meaningfully inform our theories and models.

References

Berliner, D. (1983) Developing conceptions of classroom environments: Some light on the T in classroom studies of ATI. Educational Psychologist, 18(1), 1-13.

Clark, R. (1982) Antagonism between achievement and enjoyment in ATI studies. Educational Psychologist, 17(2), 92-101.

Cronbach, L.J. (1975) Beyond the two disciplines of scientific psychology. American Psychologist, 30, 116-127.

Gagne, R.M., Ed. (1967) Learning and individual differences. Columbus, Ohio: Charles E. Merrill Books, Inc.

Gagne, R.M. (1985) The conditions of learning, 4th ed. New York: Holt, Rinehart, and Winston, Inc.

Jonassen, D.H. (1982) Aptitude- versus content- treatment interactions: Implications for instructional design. Journal of Instructional Development, 5(4), 15-27.

McCombs, B. and McDaniel, M. (1983) Individualizing through treatment matching: A necessary but not sufficient approach. Educational Communications and Technology Journal, 31(4), 213-225.

Merrill, M.D. (1983) Component display theory. In C.M. Reigeluth, Ed., Instructional design models and theories, New Jersey: Lawrence Erlbaum.

Parkhurst, P.E. and McCombs, B. (1979) Applying the ATI concept in an operational environment. Journal of Instructional Development, 3(1), 33-39.

Rothkopf, E.Z. (1981) Instructional Psychology.

Snow, R.E. (1977) Individual differences and instructional theory. Educational Researcher, 6, 11-15.

Tobias, S. (1976) Achievement-treatment interaction. Review of Educational Research, 46, 61-74.

Tobias, S. (1981) Adapting instruction to individual differences among students. Educational Psychologist, 16(2), 111-120.

Tobias, S. (1982) When do instructional methods make a difference? Educational Researcher, 11(4), 4-9.

THE EFFECT OF VARIED PRACTICE ACTIVITIES IN COMPLEMENTING VISUALIZED INSTRUCTION

Carol A. Dwyer
Instructional Designer

The Pennsylvania State University
University Park, PA

Presented at
1987 Annual Convention
Association for Educational Communications and Technology
Atlanta, GA

Abstract

The concept of individual differences has become an important instructional variable. Considerable research and theory exist which contend that if provided the right environmental conditions (practice) almost every student can be expected to achieve almost any objective. The purposes of this study were to determine: (a) whether different types of practice strategies are equally effective in facilitating the achievement of students identified as possessing high, medium and low prior knowledge levels in a content area, and (b) whether verbal and visual tests are equally effective in measuring student achievement--when the instructional content they receive is complemented by visualization. Two hundred forty students were randomly assigned to one of eight treatment groups, received a pretest, participated in their respective instructional presentation, and received a battery of tests designed to measure different educational objectives. Results indicated that practice strategies: (a) can be effective instructional variables in improving students achievement, (b) function differentially in promoting students' achievement of different educational objectives, and (c) can function to reduce differences among students possessing different levels of prior knowledge (high, medium, low). Additionally, it was found that verbal and visual tests do not appear to be equally effective in assessing information communicated by visualized instruction.

Introduction

It is doubtful whether any instructional theory will ever be developed which would universally and uniformly prescribe optimum learning environments for all students. However, instructional designers are constantly attempting to identify effective strategies for managing the learning environment to maximize student achievement. This goal has been difficult to achieve since learners possess a multiplicity of cognitive, affective, and physiological variables. Considerable research conducted in this area, utilizing various types of learners, has found that visualization of instruction, mathemagenic activities, elaborations, and generally all types of practice activities have the potential for improving students' information acquisition, storage and retrieval (Dwyer, 1978; Rothkopf, 1970; Aronson & Briggs, 1983; Gropper, 1983; Reigeluth, 1983). It is assumed that these practice variables facilitate students' encoding strategies by providing opportunities for identifying and restructuring critical information components so that new links and associations can be established.

Early research and literature in the area of manipulating learning environments (Carroll, 1963; Bruner, 1966; Bloom, 1968) contended that if the instructional environment was properly prepared and managed any student would be capable of achieving any objective. From this perspective evolved the aptitude-by-treatment orientation (Bracht, 1970; Rhetts, 1974; Cronbach & Snow, 1977) which posited that differentially designed instructional treatments would be more or less effective in promoting increased levels of achievement for different levels of students and that specifically designed instructional treatments, for specific types of learners, would function to maximize their achievement.

Closely aligned with the concept of practice activities facilitating encoding processes, Tulving and Thomson (1973) have proposed the encoding specificity principle — that memory is better if the cues used in the original instructional/acquisition environment are used in the testing/retrieval environments. Similarly, Nitsch (1977) and Battig (1979), in adhering to the encoding specificity principle, have indicated that any change in the retrieval environment from that which occurred in the original learning environment produces marked decrements in student performance.

Problem Statement

The purpose of this study was to investigate the effectiveness of different types of practice activity in facilitating encoding strategies and subsequent information acquisition and retrieval by students possessing different levels of prior knowledge (high, medium, low) in a content area. Within the context of the encoding-specificity principle, the effectiveness of verbal versus visual testing of information acquired from visually complemented instruction was also investigated. Additionally, the instructional effectiveness of both overt and covert practice activity was examined.

Specifically, the purposes of this study were to determine: (a) whether different types of practice strategies are equally effective in facilitating the achievement of students identified as possessing high, medium, and low prior knowledge levels in a content area -- or whether some types of practice activities are more effective for students at specific prior knowledge entry levels; (b) whether different types of practice activities function differentially in facilitating the achievement of students in the high, medium and low prior knowledge levels on identical objectives -- or whether some practice activities are more effective for students at specific knowledge levels and for specific types of educational objectives; and (c) whether verbal and visual tests are equally effective in measuring students' achievement of different educational objectives when students possessing different prior knowledge levels receive different practice activities --when the instructional content they receive is complemented by visualization.

Literature Review

Cognitive theory contends that when students interact with selected stimuli, they do more than merely respond to the stimuli; they relate new stimuli to existing knowledge and make combinations, inferences, abstractions, and new relationships. Through this reciprocal interplay of assimilation and accommodation, students can develop new skills and schemata that they did not possess. When this process occurs the information is said to have been encoded. Stimulating students to encode new information is not an easy task since there is a tendency for them to skip over content for which they have no immediate need or adequate referent (Doran & Holland, 1971). Practice activity allows the necessary time for both mental and physical interaction to occur and for incoming information to be held in short-term memory long enough to be elaborated upon and encoded for long-term memory (Anderson, 1980; Murray &

Mosberg, 1982). Lindsay and Norman (1972) have argued that the longer an item is maintained in short-term memory by rehearsal (practice) the greater the probability that it will be transmitted into long-term memory and be retained. Pursuing this line of reasoning, it would follow that the longer and more intense type of practice activities would provide the students with greater amounts of time to interact with the intricacies of the content and thereby provide greater opportunity for them to acquire the designated relationship. Related to this issue Travers (1970, p. 131) has stated "... attention coupled with activities involving the utilization of information are likely to be much more successful."

Practice activities exist on a continuum, each differing in the intensity of student involvement required and, thus, each type of practice may have differential effects on specific learning outcomes. If this is the case, then it may also follow that practice intensity is related to the level of learning to be accomplished -- the more complex learning requiring the more intense or involved type of practice activity. For example, covert practice (reading summary statements, reading questions and answering them mentally) generally requires less mental activity and less time than does overt practice in which the overt activity ensures that adequate time is spent interacting and encoding the information. Writing answers to questions, notetaking, and drawing diagrams may be considered to be examples of overt practice. In this respect, overt practice which requires that the learner actively work with the designated content to generate knowledge and/or produce an answer also encourages the learner to become aware of his deficiencies and provides opportunities for remediation (Bransford, Franks, Morris, and Stein, 1979). Consequently, overt practice is more likely to result in an elaborative level of processing which in turn provides the type of memory structures which facilitate both retention and retrieval. Craik and Tulving (1975), in commenting on the information-retrieval issue, have indicated that the type of rehearsal (practice) activity employed by students in interacting with the content material has many implications for the level at which information is processed and the type of information which can later be retrieved.

Justification for the use of visual test items to evaluate students' learning from visualized instruction has its generic roots in a number of hypotheses and theories (Carpenter, 1953, sign-similarity hypotheses; Hartman, 1961, stimulus generalization theory; Severin, 1967, cue summation theory; Tulving & Thomson, 1973, encoding specificity principle; Morris, Bransford and Franks, 1977, transfer-appropriate processing principle). Dwyer (1978), in reviewing the results of more than 650 articles related to the effective use of visualization in the learning process, concluded that words and pictures are not processed in the same way or are they equally effective in facilitating student achievement of different educational objectives. A number of researchers (Paivio, 1971; Nelson, et al., 1974; Jacoby, 1974; Craik & Tulving, 1975; Tulving, 1976) support this contention and have attributed the effectiveness of visualization in the learning process to the fact that visualization can be processed simultaneously on several levels. Paivio, Rogers and Smythe (1968) have suggested the possible existence of dual encoding and retrieval systems, each functioning as a separate entity with the capability to work in unison with each other. Basically, this orientation (Paivio, et al., 1968; Paivio, 1971) proposes a model involving two independent memory systems: one having the capability of processing verbal symbols, the other having the capability of processing visual information. In essence, the dual-code theory claims that information is stored in long-term memory in terms of visual images and verbal representations (Anderson, 1980). Depending on the nature (form) of the information to be retrieved, action with the specific memory system would be initiated. A number of research studies have been conducted which may be interpreted as being supportive of the dual encoding and retrieval systems (Bahrick & Boucher, 1968; Paivio & Csapo, 1969; Bahrick & Bahrick, 1971; Cermak, 1971; Ternes & Yuille, 1972; Levie & Levie, 1975).

Probably the oldest and least controversial fact that can be derived from the research on human learning is that any change in the retrieval (evaluation) environment from that which occurred in the original learning environment produces marked decrements in learner performance (Nitsch, 1977; Battig, 1979). In this regard Lindsay and Norman (1977, p. 337) have stated that in the teaching learning environment, "the problem in learning new information is not in getting the information into memory; it is making sure that it will be found later when it is needed." Consequently, information retention level is assumed to be a direct function of the encoding occurring at the presentation stage and the degree to which the retrieval environment recapitulates this encoding (Battig, 1979; Tulving, 1979). The implications of this position would imply that in instructional situations where visualization was utilized in the encoding process and was not used in the retrieval (decoding) process, learner performance measures would yield gross underestimates, if not distortions, with respect to what and how much information had been originally acquired. This conceptualization suggests that information retrieval is a very specific process, easily disrupted. Since the features of the original learning cues are processed during a test, any reduction in the individual distinctiveness of the cues themselves should produce concomitant reduction in recall (Nelson, 1979).

Optimum validity in assessment of learner information acquisition apparently can only be obtained if there is a high degree of congruency between the presentation (encoding) mode and the retrieval (evaluation) mode; e.g., if visualization is an integral component in facilitating learner encoding of the information, then visualization should also be used in the test items (decoding phase) used to assess learner achievement. Tulving and Thomson (1973, p. 359) have stated that, "only that can be retrieved that has been stored, and how it can be retrieved depends ultimately on how it was stored." Research by Thomson and Tulving (1970), Winograd and Conn (1971), Thomson (1972), Kolers (1973), Tulving and Thomson (1973), Tulving (1976), Battig (1979) and Jacoby and Craik (1979) can be cited in support of this position.

Materials and Procedure

The instructional content and evaluation materials used in this study were originally developed by Dwyer (1972), revised by Lamberski (1980), and further revised by the investigator. The instructional content which focused on the human heart, its parts, and functions contained approximately 1,800 words, and utilized 19 visuals of the heart. It was selected for use in this study because it permitted the evaluation of several different types of educational objectives directly generalizable to the classroom. Positioning of the visualization within the instructional script was determined by item analysis; visualization was placed where students had experienced difficulty in acquiring from the verbal instruction alone the information necessary to achieve on the criterion tests. Validity between the content and the criterion tests had been established by Dwyer (1972) and Dwyer and De Melo (1984).

Criterion Measures

Each student in each treatment received a 36-item physiology pretest (Dwyer, 1972) and participated in one of the instructional presentations, followed immediately by a drawing test. Each student then took three separate 20-item multiple-choice criterion tests, either in the verbal format or visual format. Scores on these three individual criterion tests (identification, terminology, and comprehension) were combined into a 60-item composite test score. The verbal format of each of the 60 multiple-choice items consisted of a typical verbal stem and verbal response options. In designing the visual test items for each criterion test, the visual tests developed by De Melo (1980) were revised by the investigator so that the final version utilized only one drawing with four or five letter labels in all items in which it was possible to do so while maintaining clarity and correspondence to the verbal test items (see Figure 1). However, two items in the terminology test and all items on the comprehension test required four drawings. The item stems of both the verbal and visual test questions were verbal and asked the same question. In addition, the visual distractors in the visual tests corresponded to the verbal distractors in the verbal tests as closely as was reasonable. The following description of the criterion tests (Dwyer, 1978) illustrates the kinds of educational objectives assessed in this study.

Figure 1 About Here

Drawing Test. The objective of the drawing test was to evaluate students' ability to construct and/or reproduce items in their appropriate context. The students were required to draw a representative diagram of the heart and place the numbers of the listed parts in their respective positions. For this test the emphasis was on the correct positioning of the verbal symbols with respect to one another and in respect to their concrete referents.

Identification Test (Verbal and Visual Format). The objective of the identification test was to evaluate students' ability to identify parts or positions of an object. This test required students to identify the numbered parts on a detailed drawing of a heart. The objective of this test was to measure the ability of the student to use visual cues to discriminate one structure from another and to associate specific parts of the heart with their proper names.

Terminology Test (Verbal and Visual Format). This test was designed to measure knowledge of specific facts, terms, and definitions. The objectives measured by this type of test are appropriate to all content areas that have an understanding of the basic elements as a prerequisite to the learning of concepts, rules, and principles.

Comprehension Test (Verbal and Visual Format). Given the location of certain parts of the heart at a particular moment of its functioning, the students were asked to determine the position of other specified parts of the heart at the same time. This test required that the students have a thorough understanding of the heart, its parts, its internal functioning, and the simultaneous processes occurring during the systolic and diastolic phases. The test was designed to measure a type of understanding in which the individual can use the information being received to explain some other phenomenon.

Total Test Score (Verbal and Visual Format). The items contained in three of the four individual criterion tests (identification, terminology, and comprehension) were combined into a 60-item total test score. The purpose was to measure total achievement of the varied levels of objectives presented in the instructional unit.

Treatments and Procedure

Four basic treatments representing different levels of practice were employed in this study. Students receiving each treatment received the same instructional script, visuals, terminology, and arrows. The four levels of practice are identified as levels of Factor A. Students receiving each of the four levels of Factor A were evaluated by either the visual or verbal test format making a total of eight experimental groups. Levels of Factor B referred to test format--Level 1 of Factor B being the verbal test format and Level 2 of Factor B being the visual test format.

Students receiving Level 1 of Factor A received no practice activity (See Figure 2, Plate 1). A practice activity was added to 18 of the 19 instructional pages for students receiving Levels 2, 3, and 4 of Factor A. Students in Level 2 of Factor A received summary statements at the end of each page that required a minimal amount of covert activity on the part of the students and did not review all the information in the instructional script. The summary statements were designed to provide the students with the opportunity for mental review of the instructional content. An example of an instructional frame received by students in Level 2 of Factor A is in Figure 2, Plate 2.

Level 3 of Factor A, represented by Figure 2, Plate 3, utilized a form of overt practice--fill-in statements immediately following each instructional page. These statements corresponded precisely to the summary statements in Level 2 of Factor A but had pertinent information omitted (one to six words). Participants were instructed to fill in the blanks, check answers at the top left of the next page, and, if incorrect, cross out the incorrect answer and write the correct answer above or to the left of the incorrect answer.

Level 4 of Factor A, represented by Figure 2, Plate 4, utilized a different form of overt practice which required that students shade with colored pencils the specified parts and functions of the heart. The parts and functions shaded corresponded to, as closely as possible, the words that were filled in the blanks in Level 3 of Factor A (see Figure 2, Plate 3. The colors used were selected to avoid a sense of color coding: black, green, yellow, and red. Red was used only in two circumstances in which four colors were required on a page; association of the red color with oxygen-rich blood was avoided.

Figure 2 About Here

Design and Analysis

Two hundred forty undergraduate and graduate students enrolled at The Pennsylvania State University participated in this study. Participants were randomly assigned to one of eight cells (N = 30) which determined both the level of practice they received and the testing mode (verbal or visual). Since one of the purposes of the study was to examine the influence that different practice strategies had on students possessing different prior knowledge levels in a content area, scores on the physiology pretest in each cell were arranged in descending order from top to bottom. The top ten scores in each cell represented the high prior knowledge level, the middle ten, the medium prior knowledge level, and the bottom ten, the low prior knowledge level.

The independent variables examined in this study were the levels of practice activity (levels of Factor A), testing mode (verbal/visual), and prior knowledge levels (High, Medium, Low). Dependent variables were student achievement scores on the different criterion tests (drawing, terminology, identification, comprehension, and composite).

Analysis of variance procedures were conducted on criterion test scores achieved by students in each of the prior knowledge levels for each of the eight cells. Data from the drawing test, for which there was only one test format, were analyzed separately. Alpha was set as the .05 level for each analysis of variance. Where significant F-ratios were found to exist, Tukey's Wholly Significant Different (WSD) procedure for comparison between two or more means was utilized. In those situations in which the Bartlett test for homogeneity of variance revealed heterogenous variances on a specific dependent measure, the heterogeneous variance option of the Tukey WSD procedure was utilized for the comparisons between means. When the heterogeneous variance option is selected, the individual variances of the subgroups being tested are averaged and used for the standard error, whereas for homogeneous variances, the standard error is the mean square within, which is the average variance of all groups involved in the particular dependent measure. This option is an application of the Behrens-Fisher statistic, t', and results in a more conservative critical value by computation of the degrees of freedom (df) using the data (that is, the n's, means, and variances). Howell and Games (1974) have shown that use of the Behrens-Fisher t' with heterogeneous variances results in control of both per comparison probability of Type I error and the family-wise probability of Type I error (FWI).

Results

The analysis of variance conducted on the pretest scores indicated that significant differences existed between students in each of the levels in the eight treatments. (See Tables 1 and 2.) Consequently, all further analyses were within treatments.

Table 1 presents the means and variances achieved by students on the criterion measures. Table 2 illustrates the results of one-way analysis on the scores achieved by students in the three prior knowledge levels (H, M, L) on each criterion test for the different treatments. Blank areas in Table 2 indicate where significant differences in achievement did not exist among students (H,M, L) on the different criterion tests. Table 3 presents the results of Tukey's WSD follow-up analysis, indicating which of the prior knowledge levels profited most from the various instructional treatments. In three instances (Drawing Test, Treatments 5 and 8; Identification Test, Treatment 1) where significant differences were found to exist (see Table 2), insignificant differences were found among the students when mean-wise comparisons were conducted on the achievement scores (see Table 3) of students in the high, medium, and low prior knowledge levels. Table 4 also illustrates the results of the mean-wise comparisons and identifies where significant differences occurred in achievement among students possessing different degrees of prior knowledge (high, medium, low) in the five criterion measures. The blank areas on Table 4 indicate where significant differences in achievement did not occur.

Discussion and Interpretation

The purpose of this study was to examine the instructional impact that different types of practice activities used to complement visualized instruction had on the achievement of students possessing different levels of prior knowledge (H, M, L). Additionally, the effectiveness of verbal and visual test formats and covert and overt practice activities was examined.

Students possessing the high prior knowledge level consistently achieved equivalent or significantly higher scores on the criterion measures than did students with low and medium prior knowledge levels, regardless of the type of practice or evaluation strategy employed (see Table 4). Additionally, the results indicated that identical practice strategies are not equally effective in facilitating the achievement of students possessing different levels of prior knowledge. Table 4 also indicates that as the complexity of the practice strategy increased (moved from covert to overt) greater positive impact was made in student performance. This increased overtness also offers to be an effective instructional technique for reducing differences in achievement between students with low and medium levels of prior knowledge on the criterion measures (Levels 3 and 4 of Factor A, Table 4). Also, it should be noticed that when students received the visual test format for Level 3 and 4 of Factor A (Treatments 6 and 8) differences which existed on the verbal test treatments (Treatments 5 and 7) disappeared.

As the practice strategies increased in complexity, their instructional effectiveness improved on each instructional objective--in terms of reducing differences among students (H, M, L). This would support the contentions of other researchers that different levels of information processing (practice) result in different degrees of information acquisition (Anderson, 1970; Craik and Lockhart, 1972; Craik & Tulving, 1975). Andre and Womack (1978) and Friedman & Richards (1981) have also reported research which supports the notion that the more deeply the material is processed the more completely it is learned. Andre (1979) has indicated that information processing can be considered to exist along a continuum extending from the superficial processing of perceptual features to intense processing for the meaning of the information.

In examining the general retrieval effects of verbal-visual test formats (Table 4, Treatments 5 & 6; 7 & 8) it appears that the visual tests were most efficient in reducing achievement differences--or in providing the appropriate evaluation environment necessary--for students in the three prior knowledge levels to retrieve acquired information. Although no comparisons to determine the relative effectiveness of treatments 5 & 6 and 7 & 8 were conducted, a visual inspection of the means (Table 1) reveals that, in general, student performance on the visual criterion tests was higher than that achieved by students receiving the verbal tests on all criterion measures for students in the three prior knowledge levels. The higher scores on the visual test may be explained by the encoding specificity principle (Battig, 1979; Nitsch, 1977; Tulving, 1979). Since the visual test situation in this study closely matched the instruction received in the initial learning situation, the visuals employed in the tests provided critical cues needed by students to retrieve the encoded information (Bransford, 1979).

Summary

The results of literature reviewed for this study indicated that students' prior knowledge level, practice strategies, and test formats were important instructional variables. This study was designed to examine how different information processing (practice) strategies influence achievement of different educational objectives by students at different levels of prior knowledge when students are evaluated in the verbal and visual test mode.

A number of summary generalizations may be derived from the results obtained in this study:

(a) Practice strategies can be effective instructional variables in facilitating student achievement from visualized instruction;

(b) Practice strategies can be effective instructional variables in reducing differences in achievement among students possessing different prior knowledge entry levels (H, M, L);

(c) Different practice strategies appear to have differential effects in promoting student achievement of different educational objectives;

(d) Verbal and visual tests do not appear to be equally effective in assessing information communicated by visualized instruction--for all types of educational objectives.

Recommendations for Further Research

Since the analysis of variance which was conducted on the pretest scores achieved by the student in the high, medium and low prior knowledge levels in the eight treatments yielded a significant F-ratio, examination of the relative effectiveness of the individual treatments (practice activities) and comparisons between the verbal/visual test formats was precluded. Consequently, all analyses conducted were in-treatment analyses which focused on the effect each treatment had on student performance where students were identified as being in the high, medium and low prior knowledge levels. Further research is needed where the pretest is administered and scored separately so that students might be randomly assigned not only to individual treatments but also to the high, medium and low knowledge levels. This procedure would enable the investigator to examine more precisely the relative instructional effects of the individual practice activities and also the relative effectiveness of the verbal and visual test formats.

Also, the utilization of additional treatments incorporating practice activities commonly used in instructional strategies would increase the fruitfulness and the generalizability of the results obtained in this study. Additionally, if delayed testing time, four and six weeks after the initial testing sequence were implemented, a more valid assessment would be obtained as to the retrieval potential of the verbal and visual tests over time.

References

Anderson, R. C. (1970). Control of student mediating processes during verbal learning and instruction. *Review of Educational Research*, *40*, 349-369.

Anderson, J. R. (1980). *Cognitive psychology and its implications*. San Francisco: W. H. Freeman and Company.

Andre, T. (1979). Does answering higher-level questions while reading facilitate productive learning? *Review of Educational Research*, *49*, 280-318.

Andre, T., & Womack, S. (1978). Verbatim and paraphrased questions and retention of meaningful sentences. *Journal of Educational Psychology*, *70*, 796-802.

Aronson, D. T., & Briggs, L. J. (1983). Contributions of Gagne and Briggs to a prescriptive model of instruction. In C. M. Reigeluth (Ed.), *Instructional design theories and models: An overview of their current status* (75-100). Hillsdale, New Jersey: Lawrence Erlbaum Associates.

Battig, W. F. (1979). The flexibility of human memory. In L. S. Cermak & F. I. M. Craik (Ed.), *Levels of processing in human memory* (23-44). Hillsdale, New Jersey: Lawrence Erlbaum Associates.

Bahrick, H. P., & Bahrick, P. (1971). Independence of verbal and visual codes of the same stimuli. *Journal of Experimental Psychology*, *91*, 344-346.

Bahrick, H. P., & Boucher, B. (1968). Retention of visual and verbal codes of the same stimuli. *Journal of Experimental Psychology*, *78*, 417-442.

Bloom, B. S. (1968). Learning for mastery. *Evaluation Comment*, *1*(2).

Bracht, G. H. (1970). Experimental factors related to aptitude treatment interactions. *Review of Educational Research*, *40*, 627-645.

Bransford, J. D. (1979). *Human cognition: Learning, understanding, and remembering*. Belmont, California: Wadsworth Publishing Company.

Bransford, J. D., Franks, J. J., Morris, C. D., & Stein, B. S. (1979). Some general constraints on learning and memory research. In L. S. Cermak & F. I. M. Craik (Eds.), *Levels of processing in human memory*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Bruner, J. (1966). *Toward a theory of instruction*. Massachusetts: Harvard University Press.

Carpenter, C. R. (1953). A theoretical orientation for instructional film research. AV Communication Review, 1, 38-52.

Carroll, J. B. (1963). A model of school learning. Teachers College Record, 64, 723-733.

Cermak, L. S. (1971). Short-term recognition memory for complex free-form figures. Psychonomic Science, 25, 209-211.

Craik, F. I. M., & Lockhart, R. S. (1972). Levels of processing: A framework for memory research. Journal of Verbal Learning and Verbal Behavior, 11, 671-684.

Craik, F. I. M., & Tulving, E. (1975). Depth of processing and the retention of words in episodic memory. Journal of Experimental Psychology: General, 104, 268-294.

Cronbach, L. J., & Snow, R. E. (1977). Aptitudes and instructional methods. New York: Irvington Press, Inc.

Dwyer, F. M. (1972). A guide for improving visualized instruction. State College, PA: Learning Services.

Dwyer, F. M. (1978). Strategies for improving visual learning. State College, PA: Learning Services.

Dwyer, F. M., & De Melo, H. (1983). The effect of visual testing in assessing the instructional potential of variables associated with visualized instruction. Journal of Instructional Psychology, 10, 126-140.

Doran, J., & Holland, J. G. (1971). Eye movements as a function of response contingencies measured by blackout techniques. Journal of Applied Behavior Analysis, 16, 11-16.

Friedman, F., & Richards. (1981). Effect of level, review, and sequence of inserted questions on text processing. Journal of Educational Psychology, 73, 427-436.

Gropper, G. L. (1983). A behavioral approach to instructional prescription in C. M. Reigeluth (Ed.), Instructional design theories and models: An overview of their current status (101-161). Hillsdale, New Jersey: Lawrence Erlbaum Associates.

Hartman, F. R. (1961). Recognition learning under multiple channel presentation and testing conditions. AV Communication Review, 9, 24-43.

Howell, J. F., & Games, P. A. (1974). The effects of variance heterogeneity on simultaneous comparison of procedures with equal sample size. British Journal of Mathematical and Statistical Psychology, 27, 72-81.

Jacoby, L. L. (1974). The role of mental contiguity in memory: Registration and retrieval effects. Journal of Verbal Learning & Verbal Behavior, 13, 483-496.

Jacoby, L. L., & Craik, F. I. M. (1979). Effects of elaboration of processing on encoding and retrieval: Trace distinctiveness and recovery of initial context. In L. S. Cermak & F. I. M. Craik (Eds.). Levels of processing in human memory (1-21). Hillsdale, New Jersey, Lawrence Erlbaum Associates.

Kolers, P. A. (1973). Remembering iterations. Memory and Cognition, 1, 347-355.

Lamberski, R. J. (1980). The effect of a verbal and visual color code on self-paced instruction and testing for retention on different tasks. Unpublished doctoral dissertation, The Pennsylvania State University.

Levie, W. H., & Levie, D. (1975). Pictorial memory processes. AV Communication Review, 23, 81-97.

Lindsay, P. H., & Norman, D. A. (1972). An introduction to psychology. New York: Academic Press, Inc.

Lindsay, P. H., & Norman, D. A. (1977). Human information processing. New York: Academic Press.

Morris, C. D., Bransford, J. D., & Franks, J. J. (1977). Levels of processing versus transfer appropriate processing. Journal of Verbal Learning and Verbal Behavior, 16, 519-533.

Murray, F. B., & Mosberg, L. (1982). Cognition and memory. In H. E. Mitzel (Ed.), Encyclopedia of Educational Research, Fifth Edition. New York: The Free Press.

Nelson, D. A. (1979). Remembering pictures and words: Appearance, significance, and name. In L. S. Cermak & F. I. M. Craik (Eds.), Levels of processing in human memory (45-76). New Jersey: Lawrence Erlbaum Associates.

Nelson, D. L., Wheelen, J. W., Borden, R. C. & Brooks, D. H. (1974). Levels of processing and cueing: Sensory vs. meaning features. Journal of Experimental Psychology, 103, 971-977.

Nitsch, K. E. (1977). Structuring decontextualized forms of knowledge. Unpublished doctoral dissertation, Vanderbilt University.

Paivio, A., & Csapo, K. (1969). Concrete-image and verbal memory codes. Journal of Experimental Psychology, 86, 279-285.

Paivio, A. (1971). Imagery and verbal processes. New York: Holt, Rinehart & Winston.

Paivio, A., Rogers, T. B. & Smythe, P. C. (1968). Why are pictures easier to recall then words? Psychonomic Science, 11, 137-138.

Reigeluth, C. M., & Stein, F. S. (1983). The elaboration theory of instruction. In C. M. Reigeluth (Ed.), Instructional-design theories and models: An overview of their current status (335-381). Hillsdale, New Jersey: Lawrence Erlbaum Associates.

Rhetts, J. E. (1974). Task learner and treatment variables in instructional design. Journal of Educational Psychology, 66, 339-347.

Rothkopf, E. Z. (1970). The concept of mathemagenic activities. Review of Educational Research, 40, 325-335.

Severin, W. J. (1967). Another look at cue summation. AV Communication Review, 15, 233-245.

Terns, W., & Yuille, J. C. (1972). Words and pictures in STM task. Journal of Experimental Psychology, 96, 78-86.

Thomson, D. M. (1972). Context effects in recognition memory. Journal of Verbal Learning & Verbal Behavior, 11, 497-511.

Thomson, D. M., & Tulving, E. (1976). Associative encoding and retrieval: Weak and strong cues. Journal of Experimental Psychology, 86, 255-262.

Travers, R. M. W. (1970). Man's information system. Scranton, PA: Chandler.

Tulving, E. (1976). Euphoric processes in recall and recognition. In J. Brown (Ed.), Recall and Recognition. New York: John Wiley and Sons.

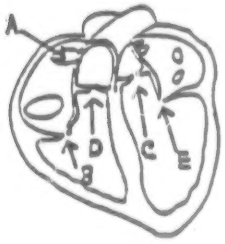
Tulving, E., & Thomson, D. M. (1973). Encoding specificity and retrieval processes in episodic memory. Psychological Review, 80, 352-373.

Tulving, E. (1979). Relation between encoding specificity and levels of processing. In L. S. Cermak & F. I. M. Craik (Eds.), Levels of processing in human memory, (405-428). Hillsdale, New Jersey: Lawrence Erlbaum Associates.

Winograd, E., & Con, C. P. (1971). Evidence from recognition memory for specific encoding of unmodified homographs. Journal of Verbal Learning & Verbal Behavior, 10, 702-706.

Plate 1. Sample questions from the identification test

aortic valve



left auricle

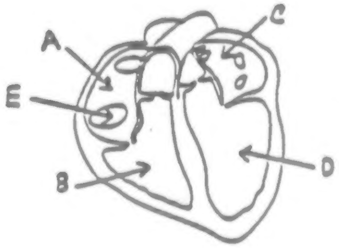
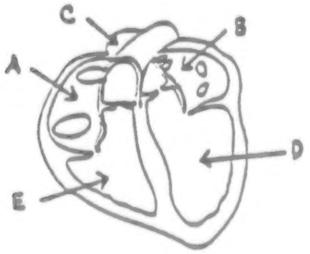


Plate 2. Sample questions from the terminology test

The chamber of the heart which pumps oxygenated blood to all parts of the body:



The part(s) of the heart which control(s) its contraction and relaxation:

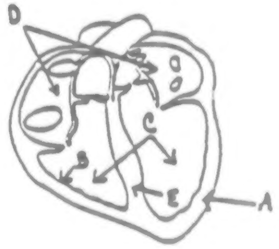
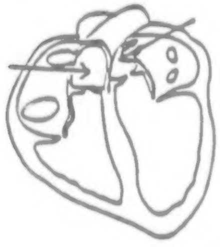
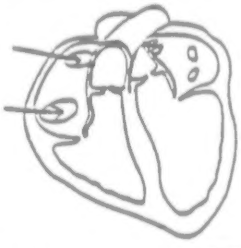
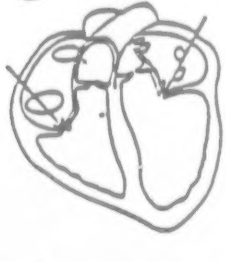


Plate 3. Sample question from the comprehension test

The parts of the heart through which blood is being forced during the second contraction of the systolic phase:







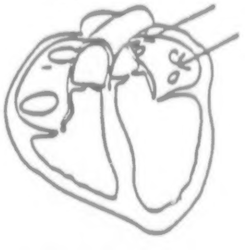
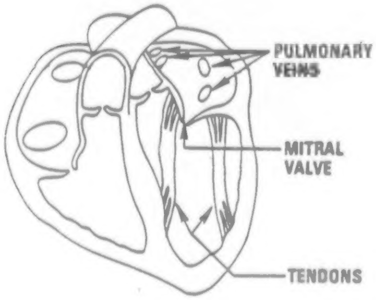


Figure [illegible]. Sample questions from the tests in the *VISUAL FORMAT*

FIGURE 2: SAMPLES OF THE PRACTICE STRATEGIES (Levels of Factor A).

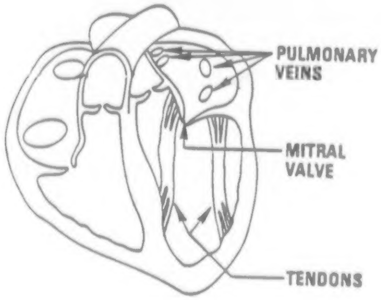
PLATE 1: VISUALIZED INSTRUCTIO



Returning from the lungs, the blood enters the heart through four pulmonary veins and collects in the left auricle; these vein openings, like the vena cavae, have no valves. The left auricle contracts when it is full, squeezing blood through the mitral valve into the left ventricle.

The mitral valve, located between the left auricle and the left ventricle, is similar in construction to the tricuspid valve. As the left ventricle contracts simultaneously with its mate, the right ventricle, it forces blood behind the flaps of the valve, thereby closing the passageway back to the left auricle. Like the tricuspid valve, the ends of the mitral valve have flaps which are anchored to the floor of the left ventricle by slender tendons.

PLATE 2: VISUALIZED INSTRUCTION PLUS COVERT
VERBAL PRACTICE: READING SUMMARIES



Returning from the lungs, the blood enters the heart through four pulmonary veins and collects in the left auricle; these vein openings, like the vena cavae, have no valves. The left auricle contracts when it is full, squeezing blood through the mitral valve into the left ventricle.

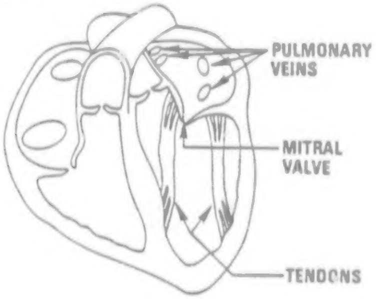
The mitral valve, located between the left auricle and the left ventricle, is similar in construction to the tricuspid valve. As the left ventricle contracts simultaneously with its mate, the right ventricle, it forces blood behind the flaps of the valve, thereby closing the passageway back to the left auricle. Like the tricuspid valve, the ends of the mitral valve have flaps which are anchored to the floor of the left ventricle by slender tendons.

(10) As the blood returns to the heart from the lungs, it enters the heart through pulmonary veins and is deposited in the left auricle.

(11) The mitral valve is located between the left auricle and the left ventricle.

PLATE 3: VISUALIZED INSTRUCTION PLUS OVERT
VERBAL PRACTICE: FILL-IN QUESTIONS

13. right
14. pulmonary



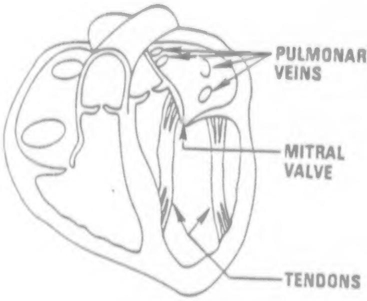
Returning from the lungs, the blood enters the heart through four pulmonary veins and collects in the left auricle; these vein openings, like the vena cavae, have no valves. The left auricle contracts when it is full, squeezing blood through the mitral valve into the left ventricle.

The mitral valve, located between the left auricle and the left ventricle, is similar in construction to the tricuspid valve. As the left ventricle contracts simultaneously with its mate, the right ventricle, it forces blood behind the flaps of the valve, thereby closing the passageway back to the left auricle. Like the tricuspid valve, the ends of the mitral valve have flaps which are anchored to the floor of the left ventricle by slender tendons.

(Q) As the blood returns to the heart from the lungs, it enters the heart through [15]______________ veins and is deposited in the [16]______________ auricle.

(Q) The [17]______________ valve is located between the left auricle and the left ventricle.

PLATE 4: VISUALIZED INSTRUCTION PLUS OVERT
VISUAL PRACTICE: SHADING ON PICTURES



Returning from the lungs, the blood enters the heart through four pulmonary veins and collects in the left auricle; these vein openings, like the vena cavae, have no valves. The left auricle contracts when it is full, squeezing blood through the mitral valve into the left ventricle.

The mitral valve, located between the left auricle and the left ventricle, is similar in construction to the tricuspid valve. As the left ventricle contracts simultaneously with its mate, the right ventricle, it forces blood behind the flaps of the valve, thereby closing the passageway back to the left auricle. Like the tricuspid valve, the ends of the mitral valve have flaps which are anchored to the floor of the left ventricle by slender tendons.

(15) Color the pulmonary veins black.

(16) Color the left auricle green.

(17) Color the mitral valve yellow.

BEST COPY AVAILABLE

Table 1. Means and Variances for Each Treatment Group on the Pretest Scores and On Each Criterion Measure

	LEVEL 1 OF FACTOR A				LEVEL 2 OF FACTOR A				LEVEL 3 OF FACTOR A				LEVEL 4 OF FACTOR A			
	TREATMENT 1		TREATMENT 2		TREATMENT 3		TREATMENT 4		TREATMENT 5		TREATMENT 6		TREATMENT 7		TREATMENT 8	
	Verbal Test		Visual Test		Verbal Test		Visual Test		Verbal Test		Visual Test		Verbal Test		Visual Test	
A. Pretest Analysis																
H	28.00	3.11	28.60	1.60	29.00	1.33	27.40	5.60	26.00	1.04	29.20	2.13	28.40	1.15	28.80	2.31
M	21.00	.89	23.40	1.60	24.20	1.96	23.20	.62	22.80	1.04	23.60	2.13	23.80	.62	22.40	2.31
L	18.00	5.78	20.40	1.60	19.00	8.89	19.20	8.62	19.40	1.04	19.80	2.13	18.60	5.60	18.40	2.31
B. Drawing Test																
H	13.20	33.73	16.10	5.47	16.50	3.61	16.30	9.43	11.10	13.18	17.50	1.67	15.40	23.60	19.20	.62
M	13.90	14.32	17.50	5.47	15.00	10.44	14.00	9.43	14.70	13.18	17.10	3.88	14.50	21.61	16.80	9.73
L	18.20	3.29	14.60	5.47	11.90	36.99	11.60	9.43	14.90	13.18	15.10	14.99	17.90	3.43	18.80	.84
C. Identification Test																
H	17.60	1.60	16.60	3.60	18.00	1.78	17.20	5.86	17.60	7.37	16.30	4.90	19.20	.84	19.00	.44
M	14.70	22.23	16.20	1.51	13.00	20.67	14.30	5.86	14.50	11.17	15.80	7.73	17.20	5.51	18.80	1.95
L	18.00	3.56	12.20	9.73	11.90	16.10	12.40	5.86	14.60	14.71	17.30	5.43	14.40	19.16	19.10	2.10
D. Terminology Test																
H	17.50	6.49	14.20	6.77	17.20	3.29	13.30	13.57	16.60	11.39	14.80	5.29	17.10	8.23	18.60	1.77
M	12.50	6.49	14.60	6.77	11.70	22.90	11.70	9.57	13.20	11.39	13.80	5.07	15.80	8.23	17.10	1.77
L	13.30	6.49	11.10	6.77	11.30	12.01	11.60	2.49	12.80	11.39	14.50	11.17	13.80	8.23	17.40	1.77
E. Comprehension																
H	15.10	7.66	14.30	5.64	14.70	16.41	13.50	19.83	14.90	9.40	13.00	3.11	16.00	9.24	18.80	.84
M	11.20	11.07	11.30	5.64	9.10	16.41	12.40	6.49	13.00	9.40	13.40	6.04	13.90	9.24	17.90	2.77
L	11.50	.72	8.00	5.64	8.00	16.41	11.00	3.11	10.10	9.40	13.00	22.67	12.50	9.24	17.90	2.32
Total Test																
H	50.00	16.44	45.00	24.61	49.90	24.77	44.00	44.98	49.10	75.31	44.10	18.77	52.30	13.12	56.60	4.71
M	39.80	95.73	43.60	24.61	33.80	183.73	38.40	44.98	40.70	75.31	43.00	20.44	46.90	50.99	50.80	88.17
L	43.00	16.22	31.30	24.61	31.20	114.84	35.00	44.98	37.50	75.31	44.80	96.40	40.60	122.49	54.00	11.77

Table 2. Analyses of Variance of Students' Achievement Scores for Each Treatment Group on Each Criterion Measure.

TREATMENTS / CRITERION TEST	LEVEL 1 OF FACTOR A		LEVEL 2 OF FACTOR A		LEVEL 3 OF FACTOR A		LEVEL 4 OF FACTOR A	
	Treatment 1 Verbal Test	Treatment 2 Visual Test	Treatment 3 Verbal Test	Treatment 4 Visual Test	Treatment 5 Verbal Test	Treatment 6 Visual Test	Treatment 7 Verbal Test	Treatment 8 Visual Test
Physiology Pretest	$F=80.80$, $df=2$, $p<.05$	$F=107.58$, $df=2$, $p<.05$	$F=61.62$, $df=2$, $p<.05$	$F=33.98$, $df=2$, $p<.05$	$F=105.04$, $df=2$, $p<.05$	$F=104.81$, $df=2$, $p<.05$	$F=97.75$, $df=2$, $p<.05$	$F=119.08$, $df=2$, $p<.05$
Drawing	$F=4.28$, $df=2$, $p<.05$	$F=3.84$, $df=2$, $p<.05$		$F=5.86$, $df=2$ $p<.05$	$F=3.47$, $df=2$ $p<.05$			$F=4.43$, $df=2$, $p<.05$
Identification	$F=3.55$, $df=2$, $p<.05$	$F=11.96$, $df=2$, $p<.05$	$F=8.23$, $df=2$, $p<.05$	$F=9.98$, $df=2$ $p<.05$			$F=6.84$, $df=2$, $p<.05$	
Terminology	$F=11.12$, $df=2$, $p<.05$	$F=5.42$, $df=2$, $p<.05$	$F=8.54$, $df=2$, $p<.05$		$F=3.83$, $df=2$, $p<.05$		$F=3.56$, $df=2$, $p<.05$	$F=3.57$, $df=2$, $p<.05$
Comprehension	$F=7.27$, $df=2$, $p<.05$	$F=17.62$, $df=2$, $p<.05$	$F=7.87$, $df=2$, $p<.05$		$F=6.22$, $df=2$, $p<.05$		$F=3.36$, $df=2$, $p<.05$	$F=1.37$, $df=2$, $p<.05$
Total Test	$F=6.36$, $df=2$, $p<.05$	$F=23.09$, $df=2$, $p<.05$	$F=9.52$, $df=2$, $p<.05$	$F=4.59$, $df=2$, $p<.05$	$F=4.77$, $df=2$, $p<.05$		$F=5.51$, $df=2$, $p<.05$	$F=2.42$, $df=2$, $p<.05$

Table 3. Tukey's Follow-up Analyses on Students' Performance for Each Treatment Group on Each Criterion Measure

CRITERION TEST / TREATMENTS	LEVEL 1 OF FACTOR A								LEVEL 2 OF FACTOR A							
	TREATMENT 1 Verbal Test				TREATMENT 2 Visual Test				TREATMENT 3 Verbal Test				TREATMENT 4 Visual Test			
		t	df	cv		t	df	cv		t	df	cv		t	df	cv
Physiology Pretest	1>2	10.60	17	2.57	1>2	14.50	27	2.48	1>3	9.89	12	2.67	1>3	6.88	17	2.57
	1>3	11.07	14	2.62	1>3	9.19	27	2.48	1>2	8.36	17	2.57	1>2	5.33	11	2.70
	2>3	3.67	12	2.67	2>3	5.30	27	2.48	2>3	4.99	13	2.69	2>3	4.16	10	2.74
Drawing	1=2	.31	15	2.60	1=2	1.34	27	2.48					1>3	3.42	27	2.48
	1=3	2.59	11	2.70	1=3	1.43	27	2.48					1=2	1.68	27	2.48
	3>2	3.24	13	2.64	2>3	2.77	27	2.48					2=3	1.75	27	2.48
Identification	1=2	1.88	10	2.74	1>3	3.81	15	2.60	1>3	4.56	11	2.70	1>3	4.43	27	2.48
	1=3	.56	16	2.58	1=2	.56	15	2.60	1>2	3.34	11	2.70	1>2	2.68	27	2.48
	1=3	2.05	12	2.67	2>3	3.77	12	2.67	2=3	.54	18	2.55	2=3	1.76	27	2.48
Terminology	1>2	4.39	27	2.48	1>3	2.66	27	2.48	1>3	4.77	14	2.62				
	1>3	3.67	27	2.48	1=2	.34	27	2.48	1>2	3.40	12	2.67				
	2=3	.70	27	2.48	2>3	3.01	27	2.48	2=3	.21	16	2.58				
Comprehension	1>3	3.93	11	2.70	1>3	5.93	27	2.48	1>3	3.70	27	2.48				
	1>2	2.85	17	2.57	1>2	2.83	27	2.48	1>2	3.09	27	2.48				
	2=1	.28	10	2.74	2>3	3.11	27	2.48	2=3	.61	27	2.48				
Total Test	1>3	3.87	18	2.55	1>3	6.18	27	2.48	1>3	5.01	13	2.64	1>3	3.00	27	2.48
	1>2	3.05	12	2.67	1=2	.63	27	2.48	1>2	3.53	11	2.70	1=2	1.87	27	2.48
	2=3	.96	12	2.67	2=3	5.54	27	2.48	2=3	.48	17	2.57	2=3	1.13	27	2.48

CRITERION TEST / TREATMENTS	LEVEL 3 OF FACTOR A								LEVEL 4 OF FACTOR A							
	TREATMENT 5 Verbal Test				TREATMENT 6 Visual Test				TREATMENT 7 Verbal Test				TREATMENT 8 Visual Test			
		t	df	cv		t	df	cv		t	df	cv		t	df	cv
Physiology Pretest	1>3	14.47	27	2.48	1>3	14.40	27	2.48	1>3	11.93	13	2.64	1>3	15.30	27	2.48
	1>2	7.01	27	2.48	1>2	8.58	27	2.48	1>2	10.93	17	2.57	1>2	9.42	27	2.48
	2>3	7.46	27	2.48	2>3	5.82	27	2.48	2>3	6.59	11	2.70	2>3	5.89	27	2.48
Drawing	1=3	2.34	27	2.48									1=3	1.05	18	2.55
	1=2	.12	27	2.48									1=2	2.36	10	2.74
	2=3	2.21	27	2.48									2=3	1.94	11	2.70
Identification									1>3	3.39	10	2.74				
									1=2	2.51	12	2.67				
									2=3	1.78	14	2.62				
Terminology	1>3	2.52	27	2.48					1>3	2.57	27	2.48	1=3	2.01	27	2.48
	1=2	2.25	27	2.48					1=2	1.01	27	2.48	1>2	2.52	27	2.48
	2=3	.26	27	2.48					2=3	1.55	27	2.48	2=3	.50	27	2.48
Comprehension	1>3	3.50	27	2.48					1>3	2.58	27	2.48				
	1=2	1.39	27	2.48					1=2	1.54	27	2.48				
	2=3	2.12	27	2.48					2=3	1.03	27	2.48				
Total Test	1>3	2.99	27	2.48					1>3	3.18	11	2.70				
	1=2	2.16	27	2.48					1=2	2.13	13	2.64				
	2=3	.83	27	2.48					2=3	1.51	15	2.60				

cv = Critical value
1 = High prior knowledge
2 = Medium prior knowledge
3 = Low prior knowledge

Table 4. Treatments Most Effective in Facilitating Student Achievement on Each Criterion Measure

	Level 1 of Factor A		Level 2 of Factor A		Level 3 of Factor A		Level 4 of Factor A	
CRITERION TESTS	Treatment 1 Verbal Test	Treatment 2 Visual Test	Treatment 3 Verbal Test	Treatment 4 Visual Test	Treatment 5 Verbal Test	Treatment 6 Visual Test	Treatment 7 Verbal Test	Treatment 8 Visual Test
A. Pretest Analysis	1 > 2 1 > 3 2 > 3	1 > 2 1 > 3 2 > 3	1 > 2 1 > 3 2 > 3	1 > 2 1 > 3 2 > 3	1 > 2 1 > 3 2 > 3	1 > 2 1 > 3 2 > 3	1 > 2 1 > 3 2 > 3	1 > 2 1 > 3 2 > 3
B. Drawing Test	3 > 2	2 > 3		1 > 3				
C. Identification Test		1 > 3 2 > 3	1 > 2 1 > 3	1 > 2 1 > 3			1 > 3	
D. Terminology Test	1 > 2 1 > 3	1 > 3 2 > 3	1 > 2 1 > 3		1 > 3		1 > 3	1 > 2
E. Comprehension Test	1 > 2 1 > 3	1 > 2 1 > 3 2 > 3	1 > 2 1 > 3		1 > 3		1 > 3	
Total Test	1 > 2 1 > 3	1 > 3	1 > 2 1 > 3	1 > 3	1 > 3		1 > 3	

1 = High entering behavior
2 = Medium entering behavior
3 = Low entering behavior

Fiction as Proof: Critical Analysis of the Form, Style, and Ideology of Educational Dramatization Films

Submitted by

Elizabeth Ellsworth
Assistant Professor
Department of Curriculum and Instruction
University of Wisconsin-Madison
225 N. Mills St.
Madison, WI 53706

To the Proceedings of the 1987 AECT Convention
Atlanta, Georgia

February, 1987

FICTION AS PROOF: CRITICAL ANALYSIS OF THE FORM, STYLE, AND IDEOLOGY OF EDUCATIONAL DRAMATIZATION FILMS

Elizabeth Ellsworth
Assistant Professor
University of Wisconsin-Madison
Department of Curriculum and Instruction

The research for this presentation was supported by a grant from The Wisconsin Center for Educational Research, University of Wisconsin-Madison.

Introduction

Some educational technology researchers have expressed a growing awareness and concern about the kinds of research questions the discipline consistently privileges. Research about how individuals learn with media dominates the field, with very little effort directed at examining the social issues raised by the production and use of educational media (Becker, 1985; Kerr, 1985; Taylor, 1985; Ellsworth and Larson, 1986; Andrews and Hakken, 1977, the Professors in Educational Technology Symposium at the 1986 AECT conference).

Questions about social issues can be posed and pursued from a number of methodological and political perspectives. In this paper, I will describe the logic and political perspective that have informed a set of questions on social issues that I am currently researching, and give some examples of the results we can expect from such an approach.

Many researchers concerned with social issues share a broad goal: to understand the relation of educational communications to the social and political processes and conditions that surround them. For a number of political and methodological reasons, I have chosen to investigate this relation by asking the following question: how do some ways of making sense of the world get privileged over others when teachers and students use specific educational films in specific learning environments?

The Need for a Critical Study of Educational Film

I have been convinced that this is a crucial line of inquiry by influential arguments employed within two disciplines concerned with mediated communication. The first is the sociology of education. This field has, in part, set for itself the task of defining and analyzing how knowledge gets constructed through social, economic, political, and ideological processes. Michael Apple has clearly stated the concerns of one highly respected position within the sociology of education: "We need to examine critically not just 'how a student acquires more knowledge' (the dominant question in our efficiency minded field), but 'why and how particular aspects of the collective culture are presented in school as objective, factual 'knowledge.' How, concretely, may official knowledge represent ideological configurations of the dominant interests in a society? How do schools legitimate these limited and partial standards of knowing as unquestioned truths? Where does knowledge come from? Whose knowledge is it? What social groups does it support?" (Apple, 1979, p. 14).

The second discipline to influence my choice of research questions is film studies. Fifteen years of intense scholarly activity around film as a cultural artefact has produced convincing arguments about how media images contribute to the ways in which our culture constitutes social categories. Film studies has raised questions about how media operate ideologically, that is, how do they form part of our society's representations of itself and part of the ways people both live out and produce those representations? (Kuhn, 1982, p. 4). Often, these representations appear in the media in ways that suggest they can be taken for granted as natural or inherently true.

All knowledge is socially constructed by people interested in perpetuating or changing aspects of the status quo. Educational institutions like schools and educational film producers working within their own sets of interests choose among competing ways of making sense of the world and privilege some over others. Educational institutions have mobilized film form and style not only to image specific types of knowledge--but to image them in ways that make them appear to be the only appropriate or True ways of making sense for everyone on all situations.

This process has major consequences for those social groups whose experiences and ways of making sense of the world do not share the interests or experiences of educational film producers. A recent analysis of films on birth and classroom response to them demonstrates how important it is for educational media producers to take the ideological nature of their work seriously. Prendergast and Prout showed that the birth films viewed by teenagers in four British "education for parenthood" courses presented birth as a "specialist subject in which (mainly male) doctors are the only recognized experts. Women's collective and individual experience and understanding of pregnancy, birth, and the transition to motherhood are subordinate to medical definitions which specify the field of relevance narrowly and mechanically around the 'pregnant patient.'" (Prendergast and Prout, 1985, p. 174). Prendergast and Prout report observing a general sense of shock among many pupils after they viewed the film, with girls appearing especially anxious and appalled, and widely expressing a desire for more information about the mother's experience and more honesty about pain. The researchers concluded in part, that:

> by comparison with a medical framework and knowledge, other knowledge pupils had, often overheard or in fragmented form from aunts, mothers or sisters-in-law, seemed weak and anecdotal. . . . Nevertheless this fragmentary knowledge hidden in the shadows, remained as a lurking suspicion that even the rather upsetting accounts presented on film as legitimate

> knowledge may not be the whole truth. Don't women who have been through it seem to be saying something different?" (p. 181-182)

The point of this example is not to suggest that the film producer could have done a better job of dispelling "old wives' tales" in favor of accurate medical "facts." Instead, I offer it as an instance in which one social group's way of making sense of the experience of birth (the male dominated medical profession's) was privileged over and above another's (women's collective and individual experience and understanding of birth), and what effects this had on the film's viewers. Further, I would argue that while the films' medical framing of birth may satisfy the needs of adult professionals working within existing medical practices, it fails miserably at framing birth in a way capable of constructing the kind of knowledge adolescents need. That is, knowledge about self-understanding, relating to others, self-confidence, values, and attitudes that adolescents need as they begin to negotiate what Prendergast and Prout call "the complex terrain of sexuality, courtship, economic and emotional dependence and independence, etc. that may bring them to the threshold of parenthood" (Prendergast and Prout, p. 181).

Methodology

My research attempts to specify precisely how educational films privilege some ways of making sense of the world over others, and how they try to make that privileging appear to be natural or inherently true.
The first step I've taken in constructing a critical analysis of educational films, is to specify how they are distinct in their form and style from other types of films. "Form" refers to ways of structuring the filmed material (such as narrative, topical, or argumentative structures); "style" to the inclusion of some stylistic elements available to filmmakers and the exclusion of others (like voice over narration, animated graphics, types of camera movements).

I drew my research sample from over 6000 nonfiction films housed at the American Archives of the Factual Film at Iowa State University in Ames, Iowa. I have chosen to define the norms of three dominant types of educational films: dramatizations, "documentary-like" educational films, and classroom teaching films.

Formalist Film Analysis. In order to define the norms of the forms, styles, and ideologies of eduational films, I have turned to methods of film analysis available from the field of film studies. Using the methodology of formalist film criticism, I am currently performing close scene by scene analyses of the films in my research sample. I have chosen formalist film criticism because it is a widely accepted analytical methodology that isolates aesthetic features of films--those features most often neglected in discussions of educational media within educational technology literature, yet essential for explaining the specificity and effects of mediated communication within education. Formalist analysis enables researchers to identify components necessary for constructing a model of the formal and stylistic norms of any film practice. Norms designate preferred practices and set limits upon invention.

Ideological Film Analysis. I am assuming that the differences in form and style that I locate between educational films and other types of films are not accidental, but are systematically related to the social, political, and educational projects of educational films and the institutions which produce and use them. The task of a critical analysis is not simply to classify films according to their norms of film form and style. Instead, critical analysis seeks to uncover ways in which form and style support the ideological project of educational films.

I am using the methodology of ideological film analysis developed by Annette Kuhn in a series of influential articles and books highly regarded within film studies. This will enable me to determine how form and style interact to legitimate some ways of making sense of the world and to marginalize others. My analysis of ideology will employ a key critical concept in film studies called "mode of address." To identify a film's mode of address is to show how the formal operations of a film solicit from the viewer a particular kind of involvement in the unfolding of the film's story or discourse. The concept of mode of address points to the fact that the film "needs" the viewer to give it its meaning. The viewer is not a passive recipient of an already meaningful message. Depending on the viewers' social, political, economic, racial, and gender positions within a culture, s/he is likely to attach a wide variety of interpretations to any one film. In an attempt to impose some limits on the kinds of meanings that viewers attach to a film, filmmakers consciously and unconsciously manipulate form and style in ways that appeal to filmmaking conventions for the purpose of setting the terms for making sense of the film.

All knowledge is socially constructed and linked to specific social, political, and economic interests. In order to make sense of the film in its own terms, the viewer must be able to adopt--if only imaginatively and temporarily--the social, political, and economic interests that are the condition for the knowledge it constructs. In this way, the the film seeks to engage the viewer not only in the activity of knowledge construction, but in the construction of knowledge from a particular social, political, and economic point of view.

My goal then, is to specify how norms of form, style, and mode of address in educational films solicit and demand from the viewer a closely circumscribed involvement in constructing a particular kind of knowledge. This will enable me to construct and support arguments about how educational film practice--as representation and institution--participates in the social and political construction of knowledge and authority.

Critical Analysis of Educational Dramatizations

Today, I would like to share some of the initial results of applying the methodologies I've described to educational dramatizations. Educational dramatizations use narrative techniques borrowed from Hollywood to present their material. My analysis attempts to specify where these films embody certain defining features of "classical Hollywood films," (CHC) and where they depart from that model. As I said, I am assuming that differences between educational dramatizations and CHC are systematically related to the political, social, and educational project of educational films and the institutions that produce and use them.

The analysis is based on a sample of 60 educational dramatizations produced between 1930 and 1970, and screened in the past six months at the American Archives of the Factual Film, Iowa State University, Ames Iowa. I have chosen films from 1930 to 1970 because this represents the period during which the aesthetic and ideological characteristics of educational dramatizations became similar and stable across films, and before significant changes in industrial practices and norms began to take place. I selected seven study films representative of the range of forms and styles apparent in the larger sample, and performed close shot by shot analyses of each. They include Film Tactics (1945), School Bus Patrol (1963), Atom Smashers (1952), Social-Sex Attitudes in Adolescence (1952), Using Visual Aids in Training (1947), A Day at the Fair (1947), and Miracle in Paradise Valley (1947).

As Kuhn has argued, the choice by educational filmmakers to borrow Hollywood narrative and stylistic techniques is a strategic one. It is an attempt to turn the ways viewers are used to making sense of narrative feature films to the service of their educational project (Kuhn, 1985, p. 101). We can also see this choice as an attempt to link the pleasure, popularity, and legitimacy of feature films to the viewing of educational films in educational settings.

But the educational project of educational dramatizations is very different from the entertainment project of Hollywood films. The project of educational dramatizations demands that viewer involvement be solicited and gratified in terms that are different from those offered by Hollywood films. I have begun to look at how educational dramatizations narrativize the aquisition of information and knowledge and invite the viewer into a specific kind of involvement in that process.

At this point, I would like to summarize some initial conclusions about how educational dramatization is different from Hollywood films in the way they construct characters. I will argue that the way an educational film constructs and uses fictional characters invites the viewer to accept a specific definition of what counts as legitimate "knowledge," and where that knowledge can be found in our culture.

Characterization in Classical Hollywood Narratives

Characterization is the engine of the narrative machine that sweeps us along in (CHC). Hollywood stories are chains of causes and effects, one thing causes another. Characters make things happen, which then have consequences for themselves and other characters. Their actions are motivated by traits of personality or individual psychology. Character goals and desires determine the series of causes and effects which propel the story forward.

The common underlying structure of CHC's chain of cause and effect is an initial problem in the fictional world that sets the story in motion. Usually it is the lack or loss of something in a character's life: manhood (seldom womanhood), love, power, ability to understand and relate to others or oneself, "meaning," etc. The rest of the film traces that character's struggle against obstacles to fill this void and reach a state of rest and plentitude.

Stories do not have to be told this way. Alternatives to character originated causes and effects include supernatural causes, natural causes, historical causes, and unmotivated coincidences. But these are seldom the causal forces in CHC and when they appear, they are usually subordinated to personalized causation. Film critics have argued that this reinforces a dominant ideological position within American culture: individualism and an ethic that places the responsibility for "success" or "failure" in society on the individual's willingness and ability to work hard within the system as it is.

What kind of viewer involvement does CHC's construction and use of characters solicit? Since characters are revealed to us in terms of their individuality and psychology, we are encouaged to identify with them emotionally. Because this is often pleasurable, we are willing to "go along" with the film and suspend our disbelief. In their exhaustive study of the form and style of classical Hollywood films, Bordwell and Thompson claim that character causality intensifies steadily from the opening scenes to the closing scenes causing a growing absorption on the part of the spectator (Bordwell and Thompson, 1985). Hollywood films try to hide the fact that someone outside of the fictional world of the story is actually constructing and manipulating the story. They do this through characterization, by implying that everything that happens in the story is the result of characters' actions and desires--not the result of an industry with particular economic, social, and political interests in telling particular types of stories. This has the effect of "naturalizing" the story: implying "that's the way people are; they made the story's events happen to them." Of course we know that the characters on the screen are not real people, but Hollywood films make it pleasurable to suspend our disbelief, identify with them emotionally, and go along with the story as if it were really happening. The film encourages us to do this by presenting characters as psychologically rounded individuals who seem to have much in common with the films' viewers. Typically, the ending is a happy one, in which the good characters' goals and desires are fulfilled.

The primary kind of viewer involvement CHC solicits then, is emotional identification with the characters, wanting to know what will happen to them next. In order to find out what happens to them next, the viewer agreeably helps to "complete" the film, to make sense of it, by recalling salient causes from earlier parts of the film and anticipating more or less likely effects in the present or coming scenes. The ending fills all the causal gaps. The result is a plentitude and linearity that seems to leave no questions unanswered, no alternatives visible or desirable. If the film has successfully enlisted our sympathies for the characters, we too are rewarded with a feeling of closure, fulfillment, and plentitude--states that do not encourage questioning the premises of the film's story or the motives of the characters; or motivate us to imagine alternative endings.

Characterization in Educational Dramatizations

While educational dramatizations borrow techniques of form and style from CHC in a strategic attempt to exploit the ways viewers are used to making sense of CHC films, the fact that the success of their educational project depends on a different kind of spectator involvement requires signficant departures from the CHC model. An analysis of the differences in how educational dramatizations use characterization can help us to specify the ideological work of educational dramatizations.

Instead of being psychologically rounded individuals distinguishable from one another by personality traits, individual goals and desires, characters in educational dramatizations tend to be representatives of social types and attitudes. In CHC, characters learn and grow through their personal experiences, finding happiness, success, and insight through the trials and pain of personal battles against forces of evil trying to keep them from their goals. But educational dramatizations consistently construct characters to appear as if they are unmotivated to learn what they do not know. If left to themselves, they would simply act out what comes "naturally" to them (like irresponsible sexual experimentation in *Social-Sex Adjustment in Adolescence*) and remain ignorant of a better way, or they would persist in their habits, traditions, or illusions that things are fine the way they have always been. Without the cause and effect chain of events resulting from characters and desires typical of CHC narratives, educational dramatizations need another kind of "glue" to hold their stories together and another kind of motivation to propel it forward. Consistently, in educational dramatizations, characters move from a state of ignorance to a state of knowledge only through the intervention of an expert. The expert may be a character in the story (like the angel in *Miracle in Paradise Valley* or the scientist in *Atom Smashers*), s/he may be a voice over narrator whom we never see (as in *Social-Sex Adjustment in Adolescence* or *A Day at the Fair*) or s/he may be a combination of voice over narrator and character as in *School Bus Patrol*, when the teacher addresses us directly from the screen to explain events, and then appears in flashbacks of events as one of the characters.

The expert is the sole enunciator of truth and knowledge in the film, sometimes speaking directly to the viewers, other times speaking to the characters for the benefit of the viewers. As soon as the expert arrives on the scene of the dramatization--either as character or as voice over narrator--the film begins an intricate interweaving of the experts' conceptual discourse on some topic and the story of the process through which characters' eyes are opened to knowledge and therefore to the "truth."

The conceptual discourse of the expert becomes the primary motivator of the form and direction of the dramatization. *Social-Sex Adjustment in Adolescence*, for example, is not segmented into dramatic scenes developed along lines of causes and effects that result from character action and their consequences. Instead, the voice of the unseen male narrator orders the events of the story into stages of social/sexual development and adjustment. The reason to change from one scene to the next is not linked to a character's actions--but instead to the next step in the narrartor's discourse about the normality of Bob and Mary's development.

Bob, Mary, and their parents function as little more than one-dimensional illustrations of the conceptual discourse of the narrator. They provide narrative evidence in support of his particular interpretation of social/sexual adjustment. The narrator defines for the viewer what goes on emotionally and physically for "normal" adolescents, and on cue, the characters act out the desires, motivations, and behaviors he attributes to them. The narrator's discourse is validated and valorized by the dramatization. The story rewards its characters for acting according to the narrators' arguments and shows the negative consequences of ignorance of his knowledge. Unlike the characters, the expert has access to knowledge capable of correcting the inadequate "natural" instincts or "misinformation" of characters, or validating those instincts born out by the conceptual discourse.

The kind of knowledge possessed by the expert is very different from that of the characters. It is analytical: capable of breaking processes and objects down into stages and elements, to reveal for us and the characters the underlying causal and structural relationships. The implciation is that if we understand the causal relations between actions and effects, we will be better able to control events and prevent negative outcomes. The expert's knowledge is also rational and linear, as opposed to experiential and intuitive. Therefore, it can be abstracted into general principles applicable to many situations, rather than linked to the personal, practical knowledge gained by people solving problems in the unique circumstances of everyday life.

Educational dramatizations encourage us to identify with the expert and her/his way of making sense of the situation in the film, over and above that of the characters. The expert is in a privileged position of knowledge and control. He defines the nature of situations, interprets characters' responses for them and to them, evaluates and corrects their behaviors, exposes their ignorance, corrects their misunderstanding or misguided behaviors. It is difficult to identify emotionally with characters who are one dimensional, often wrong, sometimes stubborn, and have no clear motives or goals. To identify with the expert on the other hand, is to be assured of a position of certainty and control. Educational dramatizations draw us into their conceptual discourses by a steady accumulation of narrative and rhetorical evidence that the expert is right, and the characters are wrong (at least ignorant).

But the "proof" offered of the expert's rightness--the guarantee that his/her knowledge is correct--is seldom presented in the form of evidence from experiments, research, or testimony about real peoples' actual experiences. Instead, educational dramatizations offer the fictional narrative as proof that the expert's knowledge is correct. Once the story's characters let the expert's knowledge guide their choices and behaviors, they are guaranteed of happy ending to their story. The expert is never wrong, and the expert is always benevolent.

The revelation of the expert's knowledge and how the characters acquire it is only half of the story of the project of educational dramatizations. As we see in other types of educational film, knowledge can be presented through a variety of formal devices like instructional designs developed for classroom teaching and documentary forms. I would like to conclude my argument by making the claim that educational films have used dramatization for the purpose of representing a particular kind of knowledge.

The dramatizations I have studied consistently imply that the characters of their stories suffer from a double lack: the lack of information about a particular subject, issue, or process; plus the lack of knowledge about how to use and/or interpret that information. The function that characterization serves in educational dramatization then, is precisely to model the proper use or interpretation of the knowledge offered by the expert. Characterization in educational films appeals to the affective domain by borrowing the viewing habits already in place for Hollywood fictional films--namely a suspension of disbelief and a readiness to identify emotionally with the characters. I have shown that the possibilities and rewards of identifying with characters in educational dramatizations are much weaker than those in CHC. Nevertheless, the point of modeling proper use and interpretation of the expert's knowledge is to have a motivational effect on the viewers--to motivate them to use their new knowledge as the fictional characters did. What educational dramatizations lack in strong characters to identify with, they make up for in rewards promised for identification. Unlike Hollywood films, educational dramatizations imply that their happy endings are not fantasies, they can come true for us, if we only put the film's knowledge to use as the characters have shown us.

"Proper use" of knowledge in these films most often means uses that lead to "positive social implications" that the film personalizes by showing their effects on the characters' lives. In my sample, positive social implications have included respect for police officers, safety on the job, patriotism, community pride civic action, effective educational strategies for training and classroom teaching, and prosocial interpersonal relations. To date, not one of the educational dramatizations I have viewed has qualified its promises of success or goodness of the project if only the viewer would acquire certain knowledge and use it properly.

Thus, the ideological work of educational dramatizations is to make a historically and culturally specific interpretation of what consititutes positive social implications and proper use and interpretation of knowledge appear to be neutral, scientific, natural, true, inherently good and benevolent. The form of educational dramatizations tries to accomplish this work by making the fictional world of the characters appear to be the real world, unaffected by the expert's discourse, and therefore able to be used as empirical evidence in support of the expert's discourse.

For example, the fictional world of the characters is made to seem to exist separately from the expert's discourse. Narrator's encourage this illusion by referring to the fictional plane of the film as being governed by natural forces outside of his/her discourse--forces like time. In Social-Sex Adjustment in Adolescence, when the narrator wished to use the experiences of characters as proof of a point in the conceptual discourse, he brings us into their separate and autonomous world with references like: "Until one day, when Bob was 16 . . ." or "meanwhile." Voice over narrators consistently explain events occurring in the story as if they were really happening, and were not constructed as illustrations of the expert's discourse. In A Day at the Fair, the narrator says: "Here in the cattle barn on the fairground, the folks are at work early, tending and grooming their cattle."

This illusion of the "reality" of the fictional plane is further reinforced when characters sometimes act autonomously and in spite of the expert's discourse. In Social-Sex Adjustment in Adolescence, Bob and Mary's parents are not controlled by the narrator's voice over. They act from their own knowledge and experience, without access to the narrator's (and the viewer's) "more complete" understanding of the situtation. As a result, they make mistakes, worry needlessly, and forget important information. The fact that the narrator does not intervene reinforces the illusion that he cannot intervene--because they are real people in the real world.

As I argued above, dramatization further guarantees the accuracy of the expert's discourse when the story rewards the characters' appropriate use of the expert's knowledge and punishes inappropriate use or ignorance. In Social-Sex Adjustment in Adolescence, images of Bob and Mary's happy wedding day are accompanied by the narrator's explanation for their happiness: "Bob and Mary had a healthy attitude toward one another as man and woman that was built up step by step since childhood," and he goes on to recount what their parents did right to prepare them for this day.

A very powerful use of dramatization to naturalize the expert's discourse is to construct stories of how characters apparently learn from their experiences in the apparently real world of the dramatization. In our culture, "experience" enjoys a privileged relationship to "reality," in that experience is seen as a direct link to the naturally occurring material forces of reality. Since the experience of characters in educational dramatizations always confirms the expert's discourse, dramatization becomes a mechanism by which the film's conceptual discourse is conflated with experience or reality.

Finally, dramatization offers a powerful mechanism for conflating social appropriateness with absolute truth. What is cast by the film as an "educational" project of modeling proper use and intepretation of knowledge for the social good is ultimately an ideological project. Educational dramatizations are interested in privileging analytical, rational knowledge arrived at through the scientific method over and above practical and intitutive knowledge arrived at through problem solving in unique contexts. Further, they are interested in privileging some applications of that knowledge over others. Dramatization aids in this project by linking the characters' motivations for acting "properly" to individualized desires, thereby removing their choices from the social domain and placing them in the personal domain. Thus, in Miracle in Paradise Valley, the experts give our hero information about the economic and social costs of farm accidents. But ultimately, he is motivated to organize people in a safety campaign only after an angel shows him the future in which neighbors suffer personal injury and loss. Likewise, in Social Sex Atttitudes in Adolescence, Bob and Mary are motivated to use their information about sex "responsibly" not out of a concern for social order and the reproduction of middle class values and a patriarchal family structure; but out of their individual desires for "meaningful love."

But educational dramatizations, like all ideological texts, ultimately fail in their attempts to conflate the social and political with the natural. Knowledge, power, and desire are often contradictory and result in gaps and silences in the relation between the expert's discourse and the character's story. While Social-Sex Adjustment in Adolescence's main project is to model proper parenting of adolescents, there are some crises and transitions in Bob and Mary's development that the expert's discourse cannot handle without exposing the social constructedness of its own values and assumptions. These crises include Mary's emotional attraction to women, Bob's experiences with mastrubation and pornography, Mary's interest in "the wrong boy;" and Bob and Mary's attraction to "inappropriate knowledge and attitudes" that come from books, jokes, peers, teenage culture, jazz music.

At these moments in the film, gaps open up in the cause-effect relations of events in the story--outcomes of characters' actions are left unexplained and unaddressed by the expert's discourse. Instead of being resolved by parental action influenced by the expert's discourse, these crises may be resolved "naturally", as when Bob and Mary "pass through a stage," without parental intervention (Mary's emotional attraction to other girls is just a phase). Or they may be resolved magically, without providing models of appropriate parental response: the wrong boy moves away before Mom has to confront the situation, Bob finds out about mastrubation and solves his "problem" with it off screen, and his mother never has to confront this issue.

Finally, some issues that cannot be addressed by the expert's discourse without revealing its values and assumptions are simply left unanswered: we never find out what went wrong with the film's "bad" kids who used their knowledge of sex inappropriately. Is the blame biological, parental, or social? In order to address this question the narrator must move his explanation of social-sex adjustment out of the domain of biology (or the natural) and into the domain of ideology (or the social and political).

The unwillngness of this educational dramatization, and the others, to admit and interrogate the social construction of knowledge and perscriptions of its proper use perpetuates the "crisis" of education we are experiencing in our culture today. Without investigating where knowlege comes from, who constructs it out of what interests, and whose experiences of the world get validated when educational media producers consciously or unconsciously adopt the conventions of educational dramatizations, educational technologists and other educators are in danger of producing at best irrelevant, and at worst, alienating and oppressive curriculum materials that systematically silence and devalue the ways that some students experience and come to understand the world.

The questions and methodologies I have outlined here today can give researchers in educational technology tools capable of beginning a historical analysis of the ideological interests of educational media producers, and how those interests have informed the form and style of media products. The purpose of such a line of inquiry is to foster a discipline that is conscious of its own assumptions, traditions, and interests--and committed to acting responsibly when it finds itself in the position of defining what counts as knowledge, and whose knowledge is to be legitimated?

References

Andrews, Barbara and David Hakken, "Educational Technology: A Theoretical Discussion," College English, vol. 19, no. 1, pp. 68-108, 1977.

Apple, Michael W., Ideology and Curriculum, London: Routledge & Kegan Paul, 1979.

Becker, Ann DeVany, "A Teaching Model for the Grammar of Television," Journal of Visual Verbal Languaging, vol. 6, no. 11, pp. 41-48, 1986.

Bordwell, David and Kristin Thompson, The Classical Hollywood Cinema: Film Style and Mode of Production to 1960, New York: Columbia University Press, 1985.

Ellsworth, Elizabeth and Margot Kennard Larson, "Critical Media Analysis, Radical Pedagogy, and MTV," Feminist Teacher, vol. 2, no. 1, pp 8-13, 1986.

Kerr, Stephen T., "Introduction: Asking New Questions About Technology and the Social World of Education," ECTJ, vol. 33, no. 1, pp. 3-8, 1985.

Kuhn, Annette, Women's Pictures: Feminism and Cinema, London: Routledge & Kegan Paul, 1982.

Kuhn, Annette, The Power of the Image: Essays on Representation and Sexuality, London: Routledge and Kegan Paul, 1985.

Prendergast, Shirley and Alan Prout, "The Natural and the Personal: Reflections on Birth Films in Schools," British Journal of Sociology of Education, vol. 6, no. 2, pp. 173-182.

Taylor, William D., "Comment: A Source of Questions," ECTJ, vol. 33, no. 1, pp. 66-69, 1985.

An Historical Analysis of Form, Style and Instructional Design in Teaching Films

Barbara Erdman

Department of Curriculum and Instruction

University of Wisconsin - Madison

It is widely assumed that educational media forms teach because they follow prescribed methods of instruction. It is further assumed that all types of mediated instruction share commmonalities of form and style, not only between themselves but also with all other teaching forms, and therefore that there are more similarities than differences between all conventional teaching methods.

If these are the assumptions that guide educational media production and use, then we can expect that the instructional motivation within each educational medium will determine the principle formal design elements and all forms of educational communication will share a characteristic style of presentation. But Sless reminds us that, "education is parasitic on the modes of communication available in our culture" (1981, p.41). Educational films for example, draw form and style from the dominant mode of filmmaking. Educational dramatizations and "trigger films" produced for educational purposes use traditional Hollywood techniques of narrative development (Newren, 1974). Educational films use the techniques of cinematography and editing which are familiar in popular films, but they adapt these stylistic qualities for their own educational needs, creating in the process another film style.

Although an estimated 25,000 non-entertainment films are produced each year (Perkins, 1982), few studies have been carried out that investigate the educational film genre. Educational film, with its own history and purpose is distinct in form from entertainment film. The specific norms which define educational films as distinct from the popular entertainment form of the classical Hollywood film, or documentary films have never been established.

Without a body of critical and historical literature to refer to, educational technologists may well assume that that the norms of educational film form and style can be traced to the widely accepted theories of instruction design, with their goals to structure the mediated lesson to the needs of the learner, and the hierarchically structured goals of instruction. But instructional design theories were not available to filmmakers before the late 1950's, while educational films were produced in great numbers from the early 1920's. Obviously strategies for making formal and stylistic choices other than Instructional Design must have guided early educational film producers.

We cannot assume that educational films simply mirror whatever instructional method has guided their production. Filmmaking is a social practice and not a simple reflection of one form of instruction into another, it necessarily transforms one type of learning event into another type. Educational films offer learning experiences that are specific to their medium.

I will address these concerns by posing a series of questions that focus on the interrelationship between instructional intent and film form and style, and on the structure of the lesson in teaching films. The questions I will attempt to answer are: What are the stylistic elements within the teaching film and how are these elements used to present epistemological content? Does the instructional component of the teaching film take on a formal or stylistic fuction in the films? In what way does the "lesson" structure the teaching film? Is the form of the filmed lesson determined by design practices prescribed by formal theories of learning and instructional design research? And finally, in what ways does educational film specifically structure the learning experience?

"Formal" norms of educational film refer to the major parts of the film and the general system of all relationships among the parts (Bordwell and Thompson, 1986, p. 383). "Stylistic" norms are defined as "repeated and salient uses of film techniques characteristic of a single film" (p. 385). All films are constructed of aesthetic elements and each type or genre of film is characterized by its own norms which are typical to that group (Schatz, 1981). The norms of any film group can be attributed to the the goals and purpose of that group. Any study of the educational film form therefore, must of necessity, concern itself first with the influence of the educational intent on the film form.

For the purpose of this study, I will confine my analysis to classroom or teaching films produced between 1930 and 1970.

Educational films are produced for a variety educational purposes and any film may be employed in diverse ways (McClusky, 1948; Wittich, 1948). Documentaries and many educational dramatizations are produced to influence attitudes and model behavior (Bluem, 1965). Teaching films however, are specifically produced to be used within the classroom to supplement classroom material, and correlate to specific lessons in the school curriculum (Wittich, 1948; Waldron, 1949). The purpose of the teaching or classroom film is to present facts, demonstrate processes or show causal relationships (Bluem, 1965). A teaching film is most commonly a 16mm, single reel, sound film, under 25 minutes in length. presented by the teacher and viewed by a class in a group setting. Because of their explicit educational purpose, teaching films are the most appropriate to the concerns of my study.

The production period between 1930 and 1970 commences just after the introduction of the 16mm film and sound technology that is prevalent in the teaching film. It includes the period when demands for educational films were the heaviest. The selection of films from this period will include films produced both before and after the development of formal models of instructional design. At the same time, it spans a period wide enough to allow for generalizations in production styles which may have been unique, or motivated by popular taste of any one particular time.

For the purpose of my study, a systematic analysis of an historical sampling of educational films will be used to provide a detailed picture of the phenomenon of educational film.

My study will be based on several assumptions that will be addressed in part in the course of the work.

The first is that educational films exist within a culture dominated by Hollywood films. In order to be intelligible to audiences, educational film in the U.S. draw from a range of formal and styles that draw heavily from traditions of Hollywood classical cinema. This historical situation will allow me to apply the categories of classical narrrative film form and style indentified by Bordwell and Thompson (1986) to the narrow genre of educational film.

My second assumption is that producers of teaching films were aware of work being done by others in the field, and that a general practice of educational film production existed. The commonalities of form and style identified within the classification of teaching film will constitute a norm, and will apply generally to all teaching films produced during the period of the study.

Forty to fifty films will be chosen for the study from the collection in the American Archives of the Factual Film at Iowa State University at Ames, Iowa. Given that this is an initital study, and given the constraints of time and resources, this will allow for a representation of films from each decade in the study. From the original sample, fifteen films which are most representative of the range of form and style will be selected for more detailed analysis.

I will produce a detailed analysis of each film by using a formalist method of film analysis defined in the work of Bordwell, Staiger and Thompson (1985) to identify the major parts of the film and the general system of all relationships among the parts and the repeated and salient uses of film techniques which are characteristic of the films.

To define the formal and stylistic elements present in each film, I will produce a detailed analysis of each film that first identifies the characteristics of its visual elements. Second, my analysis will concern itself with the audio track, the narration and sound effects and their relationship to the corresponding visual elements. Finally, my analysis will attempt to identify pedogogical principles within the design and content of each film and their relation to the formal and stylistic elements present.

Elements of lesson design and organization will be identified from prescriptions of instructional theory and practice. To accomodate films produced prior to the development of formal models of instructional design, I will identify these elements from historical textbooks on lesson design and teaching methods. In addition, I will analyze formal models of Instructional Design for elements of lesson design and apply them to my analysis of the films. Films will be compared to prescribed practices of lesson design to determine whether the logic that underlies instructional practice also underlies film form and style. Changes in the form, style, and lesson design of the filmed lesson will be traced across time.

Finally, my study will attempt to define how the medium of the educational film is a distinct kind of film and educational practice with its own conventions. It will offer a model of the teaching film produced between 1930 and 1970, that will articulate the elements of film form, style, and instructional design, and describe the relationship of these elements.

The focus of our field is on "the study of communication devices and the contraints these devices impose on the structuring, encoding, transmission, reception, and subsequent reconstruction of knowledge by learners" (Jonassen, 1984, p. 154).

Educational films construct a "media experience" which impose structural and processing requirements on learners. While it is not within the scope of my study to address specific issues of cognition and perception activities on the part of the viewer, my study will be conducted with the understanding that the teaching film, like every other educational media form developed subsequently, encourages specific activities on the part of the viewer which are in part unique to that form, and in part an adaptation of existing educational and film forms and practices. The difference in structural and processing requirements between educational media forms is a function of the nature of the individual technologies themselves as well as the cultural practices that use them.

My study will show in what way production opportunities available through the already established medium of film were utilized in conjuction with widely established prescriptions of instructional design to create the first educational media form designed for broad distribution and independent use.

Asking these questions the way that I have will contribute to an understanding of how the characteristics of a technology and the norms of its usage interact to determine the form of instruction presented by that technology. An historical analysis of how instructional intent affects film form and style; and how film form and style shape the learning experiences of educational film users, is long overdue. Such a study will bring us closer to understanding ways in which a learners's experience of educational films is not a direct result of a kind of technology, but depends upon complex interactions between viewer expectations of film, determined by the broader uses and roles of film in the culture; and the way educational filmmakers saw their work in relation to film on one hand, and available instructional designs on the other.

It is only after the distinctions between media forms can clearly be identified that the study of the comparison of the "media experience" offered through individual media technolgies can be undertaken.

REFERENCES

Bluem, William. Documentary in American Television: Form, Function and Method. New York: Hastings House, 1965.

Bordwell, David and Kristin Thompson. Film Art: An Introduction. New York: Alfred A. Knopf, 1986.

Bordwell, David, Janet Staiger and Kristin Thompson. The Classical Hollywood Cinema: Film Style and Mode of Production to 1960. New York: Columbia University Press, 1985.

Jonassen, David H. "The Mediation of Experience and Educational Technology: A Philosophical Analysis." Educational Communications and Technology, 32:3, Fall 1984, pp. 153-167.

McClusky, F. Dean. "The Nature of the Educational Film." In Film and Education: A Symposium on the Role of Film in the Field of Education. Ed. Godfrey M. Elliot. New York: Philosophical Library, 1948.

Newren, Edward F. "The Trigger Film: It's History, Production, and Utilization." Michigan University, Ann Arbor, School of Library Sciences. March 1974. ERIC ED 089 783.

Perkins, Daniel J. "The Sponsored Film: a new dimension in American film research?" Historical Journal of Film, Radio and Television. 2:2, 1982, pp. 133-9.

Schatz, Thomas. Hollywood Genres: Forulas, Filmmaking, and the Studio System. Philadelphia: Temple University Press, 1981.

Sless, David. Learning and Visual Communication. New York: John Wiley & Sons, 1981.

Waldron, Gloria. The Information Film. New York: Columbia University Press, 1949.

Wittich, W. A. "The Basic Techniques of Film Use." In Film and Education: A Symposium on the Role of the Film in the Field of Education. Ed. Godfrey M. Elliot. New York: Philosophical Library, 1948.

The Idea of the Schema

(Annual Meeting, AECT, Atlanta, March 1, 1987)

Robert M. Gagné

Florida State University

Historically speaking, the idea of the schema as a mental entity was given prominence by the work of Sir Frederick Bartlett of Cambridge University, reported in his book entitled Remembering. Bartlett obtained records of the memories people had for a story called The War of the Ghosts, about two young men who set out to hunt seals. Not only did he find that details were forgotten, but also that details were added, in such remembrances. For example, as part of the fight the two men got into, they are remembered as shooting with bows and arrows; this detail was not a part of the actual story. From the evidence of this study, Bartlett concluded that the basic entity being retained in memory was a schema, a kind of general conception of the story and its plot, into which particular details were fitted. The schema was a kind of conventional representation of the story--details that were compatible with this representation were recaptured, while others were actually constructed to fit the conventions. This general representation was what was remembered, and which Bartlett called a schema.

Although at the time this idea didn't seem to fit with the prevailing trends in memory research, it really was quite an important notion. By this later time, schema has taken its place as a key concept in various cognitive theories of learning and memory. Its applicability has been greatly expanded. For example, besides schemas for stories (Sulin & Dooling, 1974), expository passages about how things work (Bransford & Johnson, 1972), schemas are also used in organizing memories of pictures (Mandler & Johnson, 1976), and in the form of scripts, as representation of typical lifetime events like going to a restaurant (Schank & Abelson, 1977). Generally, schemas have been conceived as providing organization for declarative knowledge (verbal information), but J. R. Anderson (1983) argues strongly that this conception must not be allowed to blur the distiction between such knowledge and procedural knowledge, or what he calls production systems (intellectual skills). A production system may be viewed as a schema, but its important properties are as a procedure (or intellectual skill), in which the sequence is condition--action, and one cannot go the other way.

Definition

Since there have been all of these variations in the employment of the schema idea, is it possible to determine a definition that applies to all? Of course, people who try to interpret research findings, like those who write elementary texts, try to do this all the time. One person who has formulated the characteristics of schema is Richard Anderson (1984). His view is that comprehension of prose is a matter of "activating or constructing a schema that provides a coherent explanation of objects and events mentioned in a discourse." (p. 247). I paraphrase these characteristics as follows:

1. A schema provides a framework for taking in new information, including "slots" for thematic ideas. (Restaruant schema - waiter).

2. A schema helps the selective allocation of attention. (Where to pay close attention).

3. A schema provides a basis for making inferences. (Go beyond the literal).

4. A schema makes possible efficient memory search. (Recalling events of presidential election campaigns).

5. A schema facilitates summarizing.

6. A schema permits learner to generate hypotheses about missing information.

A schema, then, may be defined as a memory struture representing a general concept and its framework of associated concepts; the framework provides for the linking of particular details at locations (called "slots") that are established by experience with the general concept. Obviously, this definition can encompass such a schema as "going to a restaurant," and provide for the linking of particular events or items of the menu. The definition can apply to a general concept like "bagpipe" to make possible the interpretation of such a sentence as "The notes were sour because the seams split" (Bransford & McCarrell, 1974). And it can equally well apply to the kind of structures that are at work in the understanding of word problems in arithmetic, or to the structure of a geometric proof.

Schemas and Learning

According to Rumelhart (1980), and Rumelhart and Norman

(1978), there are three ways that learning can occur in individuals whose memory is schema-based. The first is called accretion, and it means simply the acquiring of new detailed facts that fit in with the structure already present.

A second process is called tuning, which means a kind of evolving change to bring the general concept in line with increased experience. New examples bring about elaboration and refinement of the concept and its structure in memory.

The third sort of change is called restructuring, and involves the creation of a new schema. This may be done (1) by copying an old one with a few modifications, "learning by analogy." A second way is called schema induction. In this case the spatio-temporal configuration becomes the basis for a new schema, without reference to analogy of a pre-existing schema. The notion of schema induction is indeed an intriguing one. Are we as human beings capable of generalizing the spacial framework of schemas without reference to their content, and by this means to invent new schemas? It may be that this is "mind boggling" in a literal sense.

Applications

The idea of the schema has been applied to the design of research in reading, writing, and arithmetic. In each of these fields, the concept of schema helps to explain the nature of the learning process involved. Can the notion of schema be used to advantage in the design of instruction? It would seem that it could be. If what is happening in learning is accretion to the schema, or tuning, or restructuring, surely these ideas should have some effect on how instruction is designed.

Here are a few ways that the schema idea might influence the design of lessons with serious learning objectives:

1. Before designing instruction for the new content to be learned, identify the pre-existing schema to which accretion or tuning is to be applied. In other words, look first for prerequisites and for the larger meaningful context into which the new learning will be fitted. As a first step in instruction, make sure that this prior knowledge--this schema--is retrieved to working memory. This is the function of the advance organizer, or the pre-test, of the set of adjunct questions, or even of the simple reminder; whatever precedes the body of the instruction itself.

2. Instruction for schema accretion. The key ideas about learning new "facts" to add to an existing structure would appear to be (a) organize, (b) provide cues for retrieval, and (c)

elaborate. These three have somewhat overlapping meanings. Learning the names of the United States may be aided by the organization of a spatial map. Such a map also provides cues for retrieval, when stored as an image. The names of states may be linked to other elaborative facts, such as the association of Vermont with the Green Mountains, or Virginia with Patrick Henry and his well-known speech. In serving these purposes, instruction may use a variety of modes, such as pictures, verbal suggestions, outlines, inserted questions, tables, and others.

3. Instruction for schema tuning. Here we are dealing with an initial crude or incomplete schema, and the instruction is designed to make the schema more accurate and complete. In the case of an intellectual skill, it would seem that the primary way of accomplishing this end is by means of practice on a variety of examples. Thus a simple schema for adding fractions such as 1/2 and 1/3 must be practiced in examples that include the addition of 5/13 plus 7/37, and also the addition of such fractions as a/b plus b/c. For verbal information (declarative knowledge), tuning a schema may be a matter of adding linked facts, but also of acquiring the interrelationships these facts have to the basic structure, so that the schema itself becomes at once more complete and more complex. What one learns in the fifth grade about the operations of the U.S. Congress is subject to tuning by the later learning that occurs by following current events, and also by later courses in American Government. The key ideas for tuning, then, are (a) variety of examples, and also (b) elaboration.

4. Instruction for schema induction. It would appear that if instruction has the purpose of schema restructuring, or schema induction, this is the place for "discovery learning." In simple cases, the learner can discover a new schema when instruction suggests an analogy. The relation between volume of a container and the pressure on its surfaces can be acquired (or induced) by using the analogy of small particles (molecules) in constant random motion. More complex analogies can be employed to induce schemas that underlie understanding of the atom and its nucleus. More rigorous uses of "discovery" may be used in complex problem-solving situations, which result in the formation of schemas identified by conceptual structures that I have called higher-order rules. Such rules are typically tied in content to the substance of the problem itself. For example, in Katona's matchstick problems, the learner may acquire the higher-order rule of "opening up the figure by eliminating shared sides," and thereby be able to solve any number of new matchstick problems. It is not at all evident that the schema concept, as such, helps us to see how to get from that point to "becoming a better problem-solver."

It seems clear, then, that the notion of schema does have some implications for understanding human learning, and therefore some useful implications for the design of instruction. As the concept becomes more precise in theory, perhaps it will yield an increased number of ideas for instruction. In the meantime, it appears to be quite compatible with other models of instruction, and to serve as a useful guide to design.

References

Sulin, R. A., & Dooling, D. J. (1974). Intrusion of a thematic idea in retention of prose. *Journal of Experimental Psychology*, *103*, 255-262.

Bransford, J. D., & Johnson, M. K. (1972). Contextual prerequisites for understanding: Some investigations of comprehension and recall. *Journal of Verbal Learning and Verbal Behavior*, *11*, 717-726.

Mandler, J. M., & Johnson, N. S. (1976). Some of the thousand words a picture is worth. *Journal of Experimental Psychology: Human Learning and Memory*, *2*, 529-540.

Schank, R., & Abelson, R. (1977). *Scripts, plans, goals, and understanding*. Hillsdale, NJ: Erlbaum.

Anderson, J. R. (1983). *The architecture of cognition*. Cambridge, MA: Harvard University Press.

Anderson, R. C. (1984). Role of the reader's schema in comprehension, learning, and memory. In R. C.

Anderson, J. Osborn, & R. J. Tierney (Eds.), *Learning to read in American schools*. Hillsdale, NJ: Erlbaum.

Bransford, J. D., & McCarrell, N. S. (1974). A sketch of a cognitive approach to comprehension. In W. B. Weimer & D. S. Palermo (Eds.), *Cognition and the symbolic processes*. Hillsdale, NJ: Erlbaum.

Rumelhart, D. E. (1980) Schemata: The building blocks of cognition. In R. J. Spiro, B. C. Bruce, & W. F. Brewer (Eds.), *Theoretical issues in reading comprehension*. Hillsdale, NJ: Erlbaum.

Rumelhart, D. E., & Norman, D. A. (1978). Accretion, tuning, and restructuring: Three modes of learning. In J. W. Cotton & R. L. Klatzky (Eds.), *Semantic factors in cognition*. Hilldale, NJ: Erlbaum.

Effects of Television and Picture Book Attributes on Children's Memory of Visual and Auditory Facts

Elinor C. Greene

Rengen Li

Brenda C. Litchfield

Department of Educational Research

The Florida State University

Tallahassee, Florida

Running Head: CHILDREN'S MEMORY OF FACTS

ABSTRACT

This study examined the effects of television and picture book attributes on children's memory of visually and verbally referenced facts. Forty-eight third grade students were first stratified by sex and then randomly assigned to view the same story in either a picture book with audiotape or a television condition. Following the story, the children were individually asked questions about specific visually and verbally referenced story content. There were no significant differences in children's recall of verbally or visually referenced facts. The unique nature of the recall measures employed, however, may have influenced these results. An unexpected finding suggested that the children who watched the televisied story recalled significantly more facts overall than the children who viewed the picture book with audiotape version. These findings are presented, and additional implications of the results are discussed.

Effects of Television and Picture Book Attributes on Children's Memory of Visual and Auditory Facts

Children are expected to learn a wide range of factual information from a variety of media sources in today's schools. However, educators rarely consider the impact of media attributes on the types of facts being learned. For example, children process both verbal and visual information when they are read to from picture books and when they view televised presentations. Few researchers have compared the effects of picture book and television attributes on children's memory of verbally and visually referenced facts.

Recent studies have been conducted to examine the effects of combinations of media attributes on children's memory of new information. Meringoff (1980) compared the effects of a television presentation and a picture book on children's recall of verbal and visual information presented via both media. She observed that children who viewed a narrated story on television remembered more story actions than children who were read to from a picture book version of the same story. However, the children who were read to from the picture book recalled more figurative language. In a related study, Beagles-Roos and Gat (1983) compared the impact of television versus radio on learning facts. They reported that children who were exposed to a televised version of a story performed better on a visual-memory test than the children exposed to a radio version of the same story. The children who listened to the radio version performed better on a verbal recall test.

Meringoff's and Beagle-Roos & Gat's research differed in terms of the media attributes they compared; however, both studies resulted in similiar findings. That is, children who viewed a televisied version of a story remembered more facts with visual characteristics than children who were exposed to either a radio or a picture book version of the same story. It should be noted that either free or cued-recall measures were used in both studies. Neither study was designed to measure children's recall of specific verbal and visual story content.

This research was designed to compare the effects of a television presentation and a picture book on children's recall of visually and verbally referenced facts. It is unique because the test items were constructed to assess recall of specific verbal and visual content.

It was expected that the children who were exposed to the televised version of the story would have greater recall of the visual, non-verbal content, and the children who were exposed to the picture book version would have greater recall of the verbal, non-visual content. The reasons for these expectations were twofold. Previous research had indicated that children who viewed a televised story remembered more visually oriented actions, whereas those who were read the same story from a picture book recalled more of the figuarative language from the story (Meringoff, 1980). Moreover, children who heard a radio version of a story performed better on a verbal-recall test than children who viewed a televised version of the same story (Beagles-Roos and Gat, 1983).

METHODS

Subjects

Subjects in this study were 48 third grade students who attend the Florida State University laboratory school. The students who attend the school are selected so that they are representative of the school age population of the state of Florida with respect to academic ability, sex, race, and socio-economic factors.

Instructional Materials

This study consisted of two conditions, a televised version and a picture book version of the African folktale A Story, A Story. Both conditions used the same audiotape and lasted 8 minutes and 29 seconds. The televised version consisted of an animated videotape. The picture book version consisted of a 32 page picture book and the audiotape. The illustrations in both versions were similiar.

A ten item test was constructed for use in both conditions to measure children's recall of verbally and visually referenced story content. The five verbally referenced test items related to facts that were stated in the audiotape but were not seen in the illustrations of either version. The five visually referenced test items related to facts that were seen in both versions but were not heard on the audiotape. The factual recall test is presented in Appendix A.

Procedure

The subjects in this study were first stratified by sex and then randomly assigned to one of the two media conditions, picture book or television. Each experimenter worked individually with children in both conditions.

An identical protocol was followed for each condition. The children were picked up at their regular classrooms and were taken to a prepared observation room. The children were told that they were going to view a short story, either in a book or on television, and to try not to interrupt until the story was over. The children who viewed the picture book sat next to the experimenter who held the book and turned the pages. The book was held equidistant between child and experimenter. In the television condition the child and experimenter sat next to each other and viewed the story together. The TV monitor was located about four feet from the viewer's chairs. The audiotape was loud enough to be easily heard in both conditions.

When the story was over, the children were told that they would be asked some questions because the experimenter was interested in finding out what they remembered. It was stated that there were no absolutely correct answers to the questions, and guessing was encouraged. In addition, the children were informed that they would receive a reward for trying their best to answer the questions. The questions were administered orally, and the children's responses were taped. Once the test was completed, the children were given their rewards and were returned to their classrooms.

Audiotapes of the children's responses were scored blind as to presentation medium. The responses were scored by judges according to predetermined criteria that had been developed for each question.

RESULTS

The dependent variable, recall of verbally and visually referenced facts, was measured by the number of correct responses to the test items. Responses to one of the visually referenced test items were not used in the analyses because the test item was determined to be ambiguous and therefore invalid. Thus, measurements used in the analyses were obtained from four visually referenced items and five verbally referenced items.

For each of the two media conditions, the obtained scores were first examined visually. The means and standard deviations caculated for each set of scores appeared consistent with the assumption of normality (see Table 1). Three F-max statistics were then applied to test the assumption of homogeneity of variance. Obtained values revealed no significant differences between the variances of the scores under each of the two dependent measures; that is, recall of verbally referenced facts, F-max (2,24) = 1.3, $p > .05$, and recall of visually referenced facts F-max (2,24) = 2.2, $p > .05$. In addition, when the verbal recall and visual recall scores for each subject were combined, the variances of the resultant set of scores did not differ significantly, F-max (2,24) = 1.97, $p > .05$.

Because the assumption of homogeneity of variance was not violated, the descriptive statistics depicted in Table 1 were determined appropriate for parametric analyses.

Insert Table 1 about here

Three one-way analyses of variance were computed to compare the performance of the two groups on both the visual and the audio sections of the factual recall test. Alpha was set at .05 for all statistical tests. The first analysis was to determine if the children who were exposed to a televised story recalled significantly more visually referenced facts than the children who were exposed to a picture book story. Although the children who watched the televisied story recalled more visually referenced facts (M = 3.0, n = 26) than those who viewed the picture book version (M = 2.5, n = 22), the results indicated that the difference was not statistically significant, F (1,46) = 3.11, p > .05.

The second analysis was to determine if the children who were exposed to a picture book recalled significantly more verbally referenced facts than the children who were exposed to a televised story. However, the children who watched the televisied story also recalled more verbally referenced facts (M = 1.9, n = 26) than the children who viewed the picture book version (M = 1.4, n = 22). The second analysis of variance failed to yield significant differences for recall of verbally referenced facts F (1,46) = 2.49, p > .05.

As indicated in Table 1, the children who viewed the televisied story performed better on both sections of the test. Moreover, when total scores on the test were compared in the third analysis, the children who watched the televisied story recalled significantly more facts (M = 4.9, n = 26) than the children who viewed the picture book (M = 3.9, n = 22), F (1,46) = 4.68, p > .05. This effect explained about 9 percent of the total variance in test performance.

Finally, it should be noted that the children in both conditions recalled a greater percentage of visually referenced facts than verbally referenced facts.

DISCUSSION

The results failed to support the major hypotheses of this research study- that children who are exposed to a televisied story will remember more visual, non-verbal story content, and that children who are exposed to a picture book story will remember more verbal, non-visual story content. Previous research (Meringoff, 1980; Beagles-Roos & Gat, 1983) suggests that there is a difference in children's recall of verbally and visually referenced facts presented via two different media attributes- audio and visual. The results of the present study are not consistent with the previous research findings.

The lack of significant results may be an artifact of the story materials which were used in this study. The story was an African folktale, and the narrator on the audiotape spoke with an accent which may have been difficult for the children to understand. Furthermore, the names of the characters were unfamiliar to the children. These two factors may have influenced the children's memory of the verbally referenced story content.

Another related factor which may have influenced the results of the study was the test. The test used in this study was unique in that it was designed to measure children's recall of specific verbal and visual story content. Tests which derived significant findings in previous studies (Meringoff, 1980; Beagle-Roos & Gat, 1983) consisted of either free or cued-recall measures. Furthermore, during test construction procedures, content analyses revealed that much of the essential story content was referenced in both the audiotape and the illustrations. Because the test items used in this study were constructed to reference only information presented via one track, i.e., audio or video, it is possible that some of the test items referenced non-memorable or trivial story content.

This research should to be replicated using different story materials. Use of appropriate materials will enable researchers to determine to what extent a given media attribute will influence children's recall of both verbally and visually referenced story content. The story selected should be unfamiliar, but the character's names should be familiar and the narration should be easy to understand. To facilitate development of relevant test items, particular emphasis should be placed on selecting a story that contains adequate amounts of essential story content represented in the narrative, and other essential content represented only in the illustrations. Clearly, further delineation of the effects of media attributes on children's recall will eventually result in improved textual materials, and increased retention of factual information.

References

Beagles-Roos, J., & Gat, I. (1983). The specific impact of radio and television on children's story comprehension. Journal of Educational Psychology, 75, 128-137.

Meringoff, L.K. (1980). Influence of the medium on children's story apprehension. Journal of Educational Psychology, 72, 240-244.

Table 1

Children's Recall of Visually and Verbally Referenced Facts

Media Condition		Facts Recalled Visually Referenced	 Verbally Referenced	 Total Recalled
Television (n = 26)	M	3.00	1.90	4.90
	SD	0.84	1.29	1.47
Picture book (n = 22)	M	2.50	1.40	3.90
	SD	1.26	1.13	2.06
Average (n = 48)	M	2.75	1.67	4.40
	SD	1.08	1.24	1.83

Note. The maximum score for visual recall is 4, the maximum score for verbal recall is 5, and the maximum score
for total recall is 9.

Appendix A

FACTUAL RECALL TEST

Narrative Questions

1. What was Ananse's nickname?
2. Where did the stories go when Ananse opened the box?
3. What did the fairy call the doll that Ananse made?
4. Osebo was called the leopard of the ____________.
5. When Ananse caught the leopard he said _________.

Visual Questions

6. After the sky God gave Ananse the stories, how did Ananse get back to earth?
7. What was Ananse holding when he talked to the sky God?
8. What was Ananse wearing?
9. Where did Ananse find the hornet's nest?
10. What did the fairy use to eat the yams?

How does the match between media and learners' preferred perceptual modes affect literacy learning?

Suzanne M. Griffin *

Supervisor, Adult Refugee Project
Office of the Washington State Superintendent of Public Instruction
FG-11 Old Capitol Building
Olympia, Washington 98504

*Ms. Griffin is a doctoral candidate in Educational Communications and Technology at University of Washington, Seattle, Washington

ABSTRACT

This study addressed two issues relevant to the effectiveness of media used in second language literacy instruction: learner-selected media versus teacher- assigned media, and media which appeals to learners' preferred perceptual modes compared with media which does not appear to match learners' preferred modes. Subjects were preliterate Hmong refugees acquiring English as a Second Language. Media of instruction were designed to appeal to one of three perceptual modes identified by the *Kerby Learning Modality Test* (1980): auditory, visual, or kinesthetic. Results showed a significant difference in achievement outcomes between learners who selected their media versus those who were assigned to media. Since many subjects did not demonstrate a dominant learning modality on the *Kerby Learning Modality Test*, the match between media and preferred perceptual modes was clear for only 13 subjects. There was no significant difference in literacy achievement outcomes between this group and learners who used media which did not clearly match their preferred perceptual modes.

Introduction

Preliterate Hmong adults have been instructed in English as a Second Language classes in the United States for more than ten years. (Since the Hmong language was not produced in written form until the mid-1950's, many Hmong adults have not experienced the process of becoming literate in their native language. Hence the term "preliterate" rather than "illiterate".) Recent studies conducted among this population (Reder, 1982; Weinstein, 1984; Hvitfeldt, 1985, 1986) indicate that these learners respond favorably to second language instruction that uses contexts and media which are familiar to them. Theoretical criteria for selecting instructional media to be used for promoting second language literacy acquisition among preliterate learners have not, however, been established.

Within the context of second language literacy acquisition, this study addressed the issues of the effectiveness of media which learners prefer (Clark, 1980) and the effectiveness of media which match the symbol systems in which learners are competent (Gross, 1974; Olson, 1974; Gardner & Perkins, 1974; and Salomon, 1979; 1981). The literacy achievement outcomes of second language learners who chose their own media of instruction was compared with the outcomes for learners who were assigned media. Further, the study investigated the relationship between learners' preferred perceptual modes--auditory, visual, or kinesthetic-- and the effectiveness of media used in instruction.

Procedures

Forty-seven Hmong refugees between the ages of 24 and 65 years of age were selected for this study. Of this group, 33 (25 females and 8 males) completed the activities of the study.

Subjects who volunteered to participate in the study were given the literacy section of the Washington State Adult Refugee Project ESL Oral Placement Test (Hargett & Callaway, 1986) to determine their literacy level in English. Those chosen for the study were able to recognize some written and printed alphabet letters in upper and lower case as well as single and double digit numbers. They could not, however, recognize more than two sight words from a list of survival words taught in ESL classes for refugees.

Following the English literacy proficiency test, subjects were given the Kerby Learning Modality Test (M.L. Kerby, 1980) to determine their preferred perceptual modes. Care was taken to explain each section in Hmong and to demonstrate what was expected of subjects. They responded better than anticipated to the test, although a few did not attempt some sections. Subjects were then assigned to one of two experimental groups or a control group. Those in the experimental groups were interviewed in Hmong about their experiences in studying languages, their exposure to the kinds of media that were to be used in the study and their preferences for media of instruction.

Three choices of media were presented to the subjects for the learning trials: 1) a video tape of hand -printed flashcards with both the English pronunciation and the Hmong translation of the phrases on the audio track; 2) a set of 5x7 glossy photographs which illustrated the phrases presented simultaneously on the flashcards; 3) a live teacher with real objects to demonstrate the meaning of information on the flashcards. The media were designed to appeal to learners' modality preferences (auditory, visual, or kinesthetic) for the way in which they discovered the meanings of the written forms presented.

The subjects in the two experimental groups were taught 15 new vocabulary words and the numerals 1-12 in three 30 minute learning sessions over a three day period. Subjects in one group were taught through the media they had chosen (live teacher demonstration or video tape with Hmong translation) and those in another group were instructed through media to which they were assigned (photographs, live teacher demonstration, or video tape with translation). In all learning sessions, subjects repeated aloud the words they were learning. Subjects in the control group were exposed to the vocabulary and numerals on flashcards for ten minutes on the first day, and then returned to their regular classes.

After three instructional sessions, subjects from the two experimental groups were individually interviewed in Hmong about their satisfaction with the media they had been using. They were also asked whether they would continue with the same media or whether they would make different choices. All subjects (including those in the control group) were then individually tested in English on the vocabulary they had been taught. The tests were given orally and consisted of four tasks written on flashcards exactly like those used in the learning sessions. Subjects were to read the task statements aloud, translate them into Hmong, and perform the task indicated (e.g. "Pick up the red pen.").

Results

There was great variability among the English literacy proficiency of subjects involved in the study. Literacy proficiency scores ranged from 1-22 out of a possible 40 points. The Kerby Learning Modality Test indicated clear modality preferences for 13 of the 27 subjects in the experimental groups: 8 auditory, 4 kinesthetic and 1 visual. The performance of 12 subjects on this test indicated no clear modality preferences. Two subjects did not complete all portions of the test.

After seeing the three possible media choices for the learning trials, 18 of the 27 subjects in the experimental groups chose a live teacher demonstration using real objects and 6 chose the video tape with the Hmong translation on the audio track. Two subjects chose the video or the live teacher demonstration and one showed no preference. None of the subjects chose the photographs presented simultaneously with flashcards. Preferred learning modalities identified by the Kerby Learning Modality Test matched with media choices made by only 11 of the 27 subjects in the two experimental groups.

The achievement outcomes for the subjects in the two experimental groups were analyzed using Analysis of Covariance. The covariate was the literacy proficiency score of each subject at the beginning of the study. The independent variable was learner selection (versus assignment) of media in the first data analysis and match to perceptual mode in the second analysis. The dependent variable was the literacy achievement score. The results for the control group were not included in the data analysis, since the group was reduced to six subjects by the end of the study.

TABLE 1

```
          ACHV
     BY   CHOICE
     WITH LIT

                            SUM OF               MEAN                SIGNIF
SOURCE OF VARIATION        SQUARES     DF      SQUARE          F       OF F

COVARIATES                9978.502      1    9978.502     20.191      0.000
  LIT                     9978.502      1    9978.502     20.191      0.000

MAIN EFFECTS               426.822      1     426.822      0.864      0.362
  CHOICE                   426.822      1     426.822      0.864      0.362

EXPLAINED                10405.324      2    5202.662     10.528      0.001

RESIDUAL                 11860.676     24     494.195

TOTAL                    22266.000     26     856.385

     27 CASES WERE PROCESSED.
      0 CASES (0.0 PCT) WERE MISSING.
```

Initial analysis of this data sample indicates that the opportunity to choose the medium of instruction did not significantly affect literacy achievement outcomes once the groups were adjusted for those in the media assignment group who drew the media they would have selected. A comparison of the achievement outcomes between the 11 subjects who used media (whether selected or assigned) that matched their preferred perceptual modes and the 16 who used media which did not match their preferred modes indicates that the match between media and preferred perceptual modes did not affect literacy achievement. Additional data analysis is planned. This analysis will include the covariates of subjects' ages, their experience using the media employed in this study, and their satisfaction with the usefulness of particular media in promoting their acquisition of second language literacy.

TABLE 2

```
          ACHV
     BY   MODE
     WITH LIT

                          SUM OF               MEAN                SIGNIF
SOURCE OF VARIATION      SQUARES     DF      SQUARE          F       OF F
_________________________________________________________________________

COVARIATES             10203.594      1   10203.594     23.060      0.000
  LIT                  10203.594      1   10203.594     23.060      0.000

MAIN EFFECTS            1075.361      1    1075.361      2.430      0.132
   MODE                 1075.361      1    1075.361      2.430      0.132

EXPLAINED              11278.955      2    5639.478     12.745      0.000

RESIDUAL               10619.712     24     442.488

TOTAL                  21898.667     26     842.256

     27 CASES WERE PROCESSED.
      0 CASES (0.0 PCT) WERE MISSING.
```

Discussion

Throughout the achievement testing process, it was apparent that auditory memory played a very important role in many subjects' attempts to "read" what was printed on the flashcards. Once they recognized a word on the card, they often recited a phrase using that word which had been on the learning trial cards rather than the phrase on the card they were encountering in the test situation. It did not seem important to some that they "read" more words than were on the card before them.

Regardless of the effect of media used on the achievement of the subjects, it was clear to the researcher and the translators that the choice of media of instruction was important to the Hmong from the standpoint of their comfort with the learning situation. They are a traditional people from an oral culture and they prefer instructional methods which include oral information and personal interaction. They do not find two dimensional visual materials--even photographs--particularly helpful in a formal learning situation.

The culture of the participants in this study had a significant impact on the procedures and the outcomes. The first impact was on the size of the sample. Of the 47 subjects who volunteered to participate, only 35 appeared to take the achievement tests on the fourth day. (Two of these were subsequently eliminated from the study because they did not fall within the guidelines for learners to be included in the study.) Severe weather had some impact on that day's attendance. It is noteworthy, however, that nine of the twelve who did not attend were in the control group. During the three days of learning trials, some members of the control group had tried to join the learning trials with the experimental groups. Translators kept re-explaining why they were not to participate in these activities, but their actions did not indicate that they completely understood the experimental situation. While the Hawthorne effect may partially account for the behavior of those in the control group, it appeared that Hmong culture was also at work in this situation.

All individual interviews with subjects, explanations of activities and specific test directions were translated into the Hmong language. This was not always easy because of differences in the linguistic structures of English and Hmong and because there are no words in Hmong for some of the activities described in the tests. Hmong has no word for "corner", for example.

The collaborative learning style characteristic of Hmong culture proved a constant challenge in testing and in individual interviews. When the Kerby test was given, the translator had to explain the necessity of students working independently. Moreover, the timing of each portion of the test had to be adjusted to the subjects' practice of discussing each new activity on the test before they attempted it. Timing of the sections of the test began after conversation stopped.

Individual interviews for literacy evaluation and for information from the learners directly conflicted with the collaborative style of the Hmong. If the interviews were conducted one-to-one in separate rooms, the interviewees became nervous. They seemed to prefer having the interviews in the room where many other activities were going on at the same time. In the latter case, the examiners constantly dealt with friends looking over the shoulders of examinees and distractions from children and other onlookers. None of the onlookers, however, tried to help examinees with answers. Nor did they seem to be using their observations to gain an advantage for their own test performance.

The use of video tape to gather information about subjects' interaction with media was not possible in the field conditions under which the study was conducted. Subjects were distributed among four different sites. All classrooms were used several times a day by different groups, so media equipment could not be set up ahead of time or left in place. Time in the classroom was limited and the principal researcher had little opportunity to withdraw enough from the instrumentation to video tape the process. Whenever the video camera was turned on, subjects stopped what they were doing and came over to look at the equipment. It was finally determined that still camera shots and audio tape recordings were less intrusive in this situation.

Cultural differences in understanding and manifesting attentiveness during the learning sessions undoubtedly affected the effectiveness of instruction by any form of media for individual subjects. Throughout the learning sessions, babies were being passed from one woman to another (two were being nursed during class); children were entering and leaving the room (3 year old twins chose to stand next to their mother and fight with each other while she tried to take an achievement test); husbands interrupted to give messages to their wives or to take them home early; and men in the learning groups simply got up and wandered over to see what others were doing. It was generally possible to keep groups of two or three subjects focused on the literacy information during the learning trials. In groups of four or more people, however, individuals were constantly distracted by another person in the group or another activity in the room.

Despite the difficulties of conducting research on media in such field conditions, it is the kind of research that will yield valid findings for an instructional situation. Laboratory studies of people from traditional cultures like the Hmong will generate skewed behavior among the participants. Moreover, laboratory conditions are so different from the situations in which formal instruction is given to this population that any finding would be of questionable value.

With the help of good translators and accurate information about the culture of the subjects, additional studies of preliterate Hmong should yield useful insights into how people from a decidedly non-technological background respond to media in educational settings. These insights should contribute to our understanding of how media is perceived by people with little or not exposure to western technology or to formal educational situations. There perception of media will have a lot to do with the effectiveness of an educational effort which must help them make the transition from an eighteenth century rural, migratory experience to a twenty-first century communication-age culture within a few months.

REFERENCES

Carrell, P. L. & Eisterhold, J. (1983). Schema theory and ESL pedagogy. TESOL Quarterly, 17 (4): 533-573.

Clark, R. E. (1982). Antagonism between achievement and enjoyment in ATI studies. Educational Psychologist, 17 (2), 92-101.

Clark, R. & Salomon, G. (1986). Media in teaching. In M. C. Wittrock (Ed.). The handbook of research on teaching. New York: Macmillan (464-468).

Gardner, H., Howard, V. A. & Perkins, D. (1974). Symbol systems: A philosophical, psychological and educational investigation. In D. Olson (Ed.). Media and symbols: The forms of expression, communication and education. 73rd Annual Yearbook of N.S.S.E. Chicago: University of Chicago Press, pp. 27-55.

Gibson, E. & Levin, H. (1975). The psychology of reading Cambridge, MA: MIT Press.

Gross, L. (1974). Modes of communication and the acquisition of symbolic competence. Media and symbols: The forms of expression, communication and education. 73rd Annual Yearbook of N.S.S.E. (pp. 56-80). Chicago: University of Chicago Press.

Hargett, G. and Callaway, D. (1986). Washington State Adult Refugee Project ESL Oral Placement Test. Olympia, WA: Superintendent of Public Instruction and Bureau of Refugee Assistance, DSHS.

Haverson, W. (1981). Literacy training for limited English speaking adult learners. In Teaching ESL to illiterate adults (pp. 23-73). (Indochinese Refugee Education Guide, Adult Education Series, No. 9). Washington, D. C.: Center for Applied Linguistics.

Hvitfeldt, C. (1985). Picture perception and interpretation among preliterate adults. Passage, 1 (1), 27-30.

Hvitfeldt, C. (1986). Traditional culture, perceptual style, and learning: The classroom behavior of Hmong adults. Adult Education Quarterly, 36 (2), 65-77.

Kerby, M. L. 1980). The Kerby Learning Modality Test. Los Angeles, CA: Western Psychological Services.

Olson, D. & Bruner, J. (1974). Learning through experience and learning through media. In D. Olson (Ed.). Media and symbols: The forms of expression, communication and education. 73rd Annual Yearbook of N.S.S.E. (pp. 125-150). Chicago: University of Chicago Press.

Ranard, D. & Haverson, W. (1981). Teaching ESL to Illiterate Adults. Washington, D. C.: Center for Applied Linguistics. (ERIC No. ED 197 628).

Reder, S. (1982). A Hmong community's acquisition of English. In B. T. Downing and D. P. Olney (Eds.). The Hmong in the West (pp. 201-225). Minneapolis: University of Minnesota.

Salomon, G. (1979). The interaction of media, cognition and learning. San Francisco: Jossey Bass.

Salomon, G. (1981). Communication and education. Beverly Hills, CA: Sage Publishing Co.

Weinstein, G. (1984). Literacy and second language acquisition: Issues and perspectives. TESOL Quarterly, 18 (3): 471-484.

I049A8.00

Psychotechnology as instructional technology:
Systems for a deliberate change in consciousness

David G. Gueulette

Professor
Instructional Technology
Dept. of Leadership and Educational Policy Studies
Northern Illinois University
DeKalb, IL 60115

Connie Hanson

Instructional Designer
Media Services
Northern Illinois University
DeKalb, IL 60115

Psychotechnology as instructional technology: Systems for a deliberate change in consciousness

> Human knowledge and power meet in one; for when the cause is not known, the effect cannot be produced. Nature to be commanded must be obeyed, and that which in contemplation is as the cause is in operation as the rule.
>
> Francis Bacon
> Aphorism III, Novum Organum

Francis Bacon's paradox, "Nature to be commanded must be obeyed" is a pertinent reminder that technologies work best to control nature by first understanding what already occurs as natural phenomena. Technology must obey nature if we are to benefit from it.

While the term "technology" generally brings to mind some piece of engineered hardware, tracing the etymology of technology to its Greek origins in the Oxford English Dictionary yields its root meaning: "systematic treatment of" or "art, craft". Technology then, is seen as a rational design for specific purpose.

Former Director of the Harvard University Program on Technology and Society, Emmanuel Mesthene said, "We have found it more useful to define technology as tools in a general sense including machines, but also including linguistic and intellectual tools and contemporary analytic and mathematical techniques. That is, we define technology as the organization of knowledge for practical purposes." (Teich, 1982, p. 102).

Winner (1977) defined technology by saying "in the West, at lest, the test is not so much what do you know or how elegant is your interpretation of worldly phenomena? but rather, what can you actually do? . . . Science succeeds over rival ways of knowing - poetry, religion, art, philosophy, the occult - not by its ability to illuminate, not even by its ability to organize knowledge, but by its ability to produce solid results . . . In the last analysis, the popular proof of science is technology" (p. 24).

Yet Schramm's summation of instructional technology research is replete with examples of technologies which have failed to bring about significant effects in learning (Schramm, 1977). Radio, film, television and computer, though remarkable scientific achievements in themselves, have generally proven powerless to dramatically improve one's ability to learn.

Winn (1984) has expressed some disenchantment with electronic media as instructional tools, pointing rather to the positive attributes of instructional methods which "interact with psychological processes in learners and thus have a direct influence on how they learn" (p. 31).

Technology which does not interact with a learner's thought processes is simply hardware. Yet directed thought may be considered an advanced technology. The value of any instructional technology rests on its ability to deliberately interact with a learner.

Instructional Technology research in the past usually has neglected to study the mind of the learner. Rather, teaching technologies often have been vigorously researched to determine whether any relationship existed between a stimulus such as film and some learning response. No significant correlations were generally found (Schramm, 1977).

However, the subjective mind of man has now become a respectable research topic for educators. In a review of consciousness research, Hilgard noted "the preference for the externally observable (peripheralism, the 'fingertip' psychology) against private mental experiences (centralism) led to a distaste for studying mental processes such as imagery. When consciousness began to be studied in the spirit of cognitive psychology, it was described as the "return of the ostracized," (1980, p.8). The visual literacy movement which includes such topics as mental rehearsal and visual thinking underlines this shift to looking at internal mental processes in the field of instructional technology. Perhaps as we change the emphasis of our research and examine new processes by which learners can perceive and assimilate information, we can discover additional ways to expand their capabilities.

A report issued by the Department of Health Education and Welfare addressed this issue. "The Outer Limits of Human Educability: A Proposed Research Program" It stated that various approaches have been developed to, "increase the range of these receptors and to increase the rate and complexity of an organism's capacity to assimilate experience" (Fletcher, 1978, p. 15). Also noted in the report, "there are various approaches to increasing storage, retrieval and creative synthesis powers of the organism" (p. 15). As the report stated, some approaches seek to alter our senses, "to increase the rate of input, or the accuracy of sensory discrimination" (p. 15), or, "to determine whether under hypnosis, meditation, or other altered stated of consciousness, the senses operate more efficiently" (p. 15), or, "since one's concepts, expectations, and experiences affect what is perceived . . . to provide internal categories for the material to be assimilated" (p. 15), using a technique such as guided fantasy.

Other approaches were said to, "discriminate in great detail the body's reaction to something because internal sensations often mirror something that is happening outside" (p. 15). Still other approaches involve looking inward through meditation and psychotherapy in the belief that "the world outside a person reflects what is true inside and is set up to complement it (p. 15). Additional ways to develop our capacity to process experience stated in the report were: by developing non-linear ways of processing information through analogy, metaphor, myth and personification.

In fact, many researchers and practitioners are investigating whether it is possible to affect an individual's learning ability through psychotechnology. Dr. Jean Houston, director of the Foundation for Mind Research, said, "We have discovered, for example, that most people, given an opportunity and education, can realize more of their potentials in varying degrees. They can learn to think in images as well as in words, to practice in subjective time the rehearsal of skills, and to experience the acceleration of thought processes. They can experience cross-sensing, the self-regulation of pleasure and pain, and acquire voluntary control over some of the autonomic functions by means of biofeedback and autogenic training" (Battung, 1981, p. 15).

Dr. Tom Roberts, Northern Illinois University professor, described psychotechnology this way. "As students become aware of their own inner states, they can begin to recognize important conditions which affect their learning ability" (1975, p. 5). He then explained how relaxation training, guided fantasy, dream work, meditation and biofeedback may improve a students performance in the classroom by enabling him to enter a state of mind which is conducive to learning.

While explaining what he called "The New Copernican Revolution," Dr. Willis Harman, from Stanford University, observed that "much evidence is accumulated to support these three propositions: 1) human potential is far greater than our present models allow 2) a far greater portion of our experience is unconscious than we acknowledge and that these unconscious processes are facilitated by attending to feelings and emotions through such means as inner attention, free association, hypnosis, sensory deprivation or psychedelic drugs 3) that expectations (largely unconscious) play a dominant role in enhancing or limiting our capabilities" (1969, p. 28).

In her book, Supermind, Dr. Barbara Brown stated that "mind techniques of self-suggestion, imagery, healing powers, changing consciousness, body consciousness, inner games of sports, mind-body integration, the meaning of Zen writings, yogic meditation, and other variations on the theme of mind all signal a new perception of mind (1980, p. 7) which point to the "emergence of a human superpotential, a new mind" (p. 9).

Approaches such as these which apparently engage the psychological processes of the learner are often referred to as "psychotechnologies" (Ferguson, 1980, p. 87). Other examples of psychotechnology which Ferguson identified were: autogenic training, music, improvisational theatre, hypnosis, meditation, sensory isolation and overload, body disciplines such as hatha yoga, aikido and karate, and biofeedback.

With the emergence of these psychotechnologies, Ferguson observed, "Some eminently sane and distinguished people believe that the human mind may have reached a new state in its evolution, an unlocking of potential comparable to the emergence of language" (Ferguson, 1980, p. 67).

What more do we know of psychotechnologies? "The intentional triggers of transformative experiences are numberless, yet they have a common quality. They focus awareness on awareness - a critical shift. For all their surface variation, most focus on something to strange, complex, diffuse, or monotonous to be handled by the brain's analytical, intellectual half; on breathing, repetitious physical movement, music, water, a flame, a meaningless sound, a blank wall, a koan, a paradox. The intellectual brain can only dominate awareness by affixing itself to something definite and bounded. If it is captured by a diffuse, monotonous focus, the signals from the other side of the mind can be heard" (Ferguson, 1980, P. 85).

The governmental report "The Outer Limits to Human Educability" concurred, suggested that, "Some forms of meditation are used to 'stop the mind' to eliminate the cognitive noise or dissonance that for most of us is always present. Apparently eliminating that process opens the awareness to many other forms of knowledge that were still masked by cognition (Fletcher, 1978, p.14).

A predominant theory is that they are tools to other realms of consciousness, whether it is the preconscious (Lozanov, 1976), an altered state of consciousness (Tart, 1969), or the unconscious (Brown, 1980). Implicit to this is the assumption that other realms or states of consciousness are the source of greater creativity, problem-solving ability, supermemory, and heightened awareness.

Roberts (1981) described it this way. Human disabilities and disabilities are stronger in some states of consciousness and weaker or nonexistent in others. "As one learns to select one's state of consciousness (patterns of mental functioning), one increases the number of abilities one can learn, develop and use" (p. 106). "If someone tries to deny the importance of all different mental patterns, he is stuck with the fact that these experiences are frequently psychologically therapeutic, philosophically insightful and both artistically and scientifically creative (1983b, p. 2).

Lozanov agreed. "For example, D. Mendeleev completed his work on the periodic table of the chemical elements during a dream. A. Kekule von Stradonitz solved the problem of the structure of the benzene nucleus in his sleep; and S. T. Coleridge envisioned Kubla Khan while drugged by a medicinal potion, and then wrote this poem" (1976, p. 75).

Considering consciousness, William James, in The Varieties of Religious Experiences (1929), established it as a significant issue which is germane to the field of psychology and indirectly, education.

> Rational consciousness . . . is but one special type of consciousness, whilst all about it, parted from it from the filmiest of screens, there lie potential forms of consciousness entirely different. We may go through life without suspecting their existence; but apply the requisite stimulus, and at a touch they are there in all their completeness. No account of the universe in its totality can be final which leaves these other forms of consciousness quite disregarded. How to regard them is the question . . . At any rate, they forbid a premature closing of our accounts with reality" (p. 89).

Other prominent psychologists have investigated the work of the unconscious using psychotechnology. Some developed extensive theories which where later applied to education.

Sigmund Freud, using such techniques as hypnosis, dream analysis and free association, discovered many ways in which the unconscious influenced behavior. Freud later conceptualized the data generated by these techniques, laying the groundwork for theories of personality development. Many have applied Freud's concepts to education. Four Psychologies Applied to Education (Roberts, 1975) includes sixteen articles describing some implications of Freudian psychology for educators.

Freud's disciple, Carl Jung, also studied the unconscious, primarily through dreamwork and symbolization. But unlike Freud, he theorized that the fundamental instinct within man was not sex drive, but creative impulse (Wilson, et al, 1969, p. 333). Jung believed that claiming unconscious aspects of the self freed an individual from restricting emotions. He portrayed this maturational process as individuation. (Owen, et al, 1981, p. 117).

The same tools have been used for a different purpose. Many of the techniques of Freudian psychology which were used to explain the abnormal, have become the tools of transpersonal psychology to explore the supernormal. The evolution from Freudian psychology to transpersonal psychology, however, was partly owing to contribution from Humanistic Psychology.

Father of Humanistic Psychology, Abraham Maslow, held a, "belief in the reality of higher human needs, motives and capacities" (Roberts, 1975, p. 306). The Farther Reaches of Human Nature outlined these Higher goals. Proposing such concepts as self-actualization, self-transcendence, and peak experiences, Maslow emphasized the stages of development beyond mere survival. Humanistic Psychology emphasized the positive attributes of man. "These positive abilities are called human potentials and humanistic educators usually focus their teaching on these abilities" (Roberts, 1975, p. 29).

Many well-respected psychologist belong to this movement. "The human potential movement is a serious, influential, and revolutionary trend, built on the work of Abraha Maslow, Jean Piaget, Erich Fromm, Alexander Lowen, and Rollo May, among others, and on the brain research that stemmed in part from work with brain wounded soldiers in World War II" (Robinson, 1977, p. 638).

Humanistic Psychology and "Third Force Psychologies" (Roberts, 1975), gave rise to transpersonal psychology, an emerging psychology which contends that human potential is extraordinary and far surpasses current expectations. The "Fourth Force" (Tart, 1975) includes the study of unusual abilities such as extrasensory perception, psychokinesis, supermemory, and experiences which relate to the spiritual nature of man. "While the humanistic psychologists tend to explore interpersonal, human relations in their search for these new potentialities, transpersonal psychologists trend toward the subjective, transcendent, and more unusual attributes" (Roberts, 1975, p. 396).

In an even broader sense, many have observed that the exploration of these new abilities represents a new view of man. This new view of man is considered to be part of a paradigm shift which challenges many traditional assumptions of Western science. Fritjof Capra, professor of physics, characterized this new paradigm in The Turning Point. Referring to unemployment, high inflation and other modern problems, he stated, "The basic thesis of this book is that these are all different facets of one and the same crisis, and that this crisis is essentially a crisis of perception" (1982, p. 15). Capra's view is partially derived from the new physics which now recognizes that "the basic structures of the material world are determined, ultimately, by the way we look at this world; that the observed patterns of matter are reflections of patterns of mind" (Capra, 1982, p. 93). Thus additional credence is given to conceptual awareness.

In The Aquarian Conspiracy, Ferguson explicated this paradigm shift as a broad social movement - cultural transformation based on personal transformation. Psychotechnology, according to Ferguson, provides the tools for personal transformation and a new view of man. She expects that this new view of man will engender radical changes in every corner of society - politics, business, and education as well.

While psychotechnology may provide tools to accomplish very specific instructional goals, others see it as much more than that. As history suggests, the function of psychotechnology varies with the user. How can psychotechnologies serve instructional technologists?

Evidence can be found to show that psychotechnology can:

a) Augment instructional design models
b) Generate extraordinary learning outcomes
c) Provide additional cognitive strategies to improve one's ability to learn
d) Auger a future trend in the definition of instructional technology

Emerging physiological evidence and theories point to the inadequacy of the information processing model currently used in most instructional design work. The evidence points to the interrelationship between mind and body and the need to design instruction which addresses this fact.

Psychotechnology embraces the idea that, "The conceptual merger of body and mind also implies that, at bottom, psychology is not all that different from physiology. Life's experiences, it turns out, alter the cellular and chemical arrangements of the brain" (Alexander, 1983, p. 83). The bodymind connection underlies many psychotechnologies. "Not only does the body reflect all the historical and present conflicts of the mind, but the reorganization of one helps reorganize the other . . . Intervention anywhere in the dynamic bodymind loop affects the whole" (Ferguson, 1980, p. 102). A discussion of body therapies noted that "mind can be seen as an aggregate of the total multisensory pictures of successive moments of now. This continuous stream includes innumerable inputs from the body, in varying degrees of conscious awareness - position, muscle tone, temperature, the condition of internal organs and processes. Thus it can be seen that the state of the body is part of mind, and it follows that changes in the body are reflected as a changed mental state" (Rappaport, 1975, p. 66).

What physiological evidence suggests that psychotechnologies may enhance learning? According to brain researcher, Marilyn Ferguson, "Meditation, chanting, and similar techniques increase the coherence and harmony in brain wave patterns; they bring about greater synchrony between the hemispheres, which suggests that higher order is achieved. On occasion it appears that increasing populations of nerve cells are recruited into the rhythm, until all regions of the brain seem to be throbbing, as if choreographed and orchestrated. The usually dissynchronous patterns in the two sides seem to become entrained to each other. Brain wave activity in older, deeper brain structures may also show an unexpected synchrony with the neocortex" (1980, p. 79).

In a recent Delphi Survey, Diane Battung identified over 45 new developments in the brain/mind revolution which corroborate the validity of psychotechnologies as instructional tools. The following is a partial list of some of the evidence available.

Some brain/mind theorists speculated that relaxation exercises may be useful by reasoning that anxiety which produces static in the brain (as shown by brain wave scans) can inhibit learning. Others conjectured that the brain may respond to music and rhythmic approaches because according to Karl Pribram's holographic theory, the brain resonates to mathematically processed frequencies. Similarly, microdynamic theorists stated that every physical material carries a harmonic and that "the brain may operate as a resonating system whereby neurochemicals in the brain are brought into symmetrical formats by the central resonances" (1980, p. 45). It has been suggested that an alternate state of consciousness may enhance one's memory by producing more endorphins (chemicals in the brain which evidently have an effect on memory) explaining perhaps why hypnosis can elicit remarkable feats of memory.

Joseph Bogen reported that information which is emotionally loaded is transmitted quickly because most information passes through the brain stem which is richly connected to the limbic (emotional) system (Battung, 1982, p. 20). This may be one rationale for using technique such as psychodrama which attempt to elicit an emotional response. A multisensory approach may be advisable because as some reported, in order for information from short term memory (electrical) to be transferred to long term memory (chemical) three or more senses must be involved. It was noted that physical therapies have already demonstrated that body movement can stimulate the brain, so such body therapies as the Feldenkrais Method and Alexander technique which appear to be effective psychotherapies may be useful tools for interacting with the mind. It was disclosed that the brain has the ability to process millions of pieces of information in microseconds so that it may be possible to accelerate learning far beyond what is usually possible.

Battung concluded her study by saying that "It was evident from the literature reviewed that developments contributed to the study by both the Panel of Eminence and participants are issues in the brain/mind revolution and are directly linked with the human capacity to learn and the processes of education" (p. 259).

Together with emerging physiological data, new theories are being developed which point to the inadequacy of current instructional design practices and the potential value of psychotechnology.

Howard Gardener, former staff member of the Harvard Project on Human Potential, raised some issues. "For one thing, like most previous approaches to intelligence, the information processing tack is studiously non- (if not anti-) biological, making little contact with what is known about the operation of the nervous system" (1983, p. 23). Instead, Gardener proposed a theory of multiple intelligences, each autonomous systems for perceiving, processing and storing information. The seven intelligences he convincingly argued are: musical, bodily kinaesthetic, spatial, linguistic, personal, and logical-mathematical. He remarked that each intelligence appeared to have its own symbol system, i.e., that "symbol systems may have evolved just in those cases where there exists a computational capacity ripe for harnessing by the culture" (Gardener, p. 66). A reasonable conjecture may be that some psychotechnologies which introduce music, psychodrama, kinaesthetic or spatial awareness, may provide alternate ways to communicate with these other intelligences. While this is pure speculation, Gardener's theory is too suggestive to be ignored.

Norman Geschwind, Professor of Neurology at Harvard agreed that, "Other neurological evidence points to an organization of the brain which is composed of multiple systems and these different systems are often at a distance from each other and under quite different kinds of control" (Miller, 1983, p. 127). A psychotechnology such as hypnosis may enable a learner to bypass normal controls in the conscious mind - repressions, defenses, and inhibitions, and access what Lozanov refers to as the "hidden reserves" of the mind. These hidden reserves may hold lost memories and stifled abilities. Dreamwork and meditation may also avert conscious controls and enable a learner to reclaim what only exists now as a potential.

Alan Allport also stated that the mind "is best thought of as a large number of independent production systems; these computational systems operate in parallel (rather than serially) and are each specifically keyed to and activated by a certain kind of information. (Gardener, 1983, p. 28). Ivan Barzakov's program, Optimalearning, orchestrates paintings, classical music, skits, posters and stage props to suggest the same message to the student. His belief in the power of suggestion implies that although the learner may not consciously be aware of each message in the environment, some other part of him still perceives and processes it. This challenges current instructional design practice. As Wittrock has pointed out "Instruction using a single objective at a time, or an assumption that a single meaning corresponding to a meaning given by a teacher is learned is naive. A variety of organizations, strategies of information processing, and sequences of instruction for different contexts, people and subject matter seems more likely to accommodate the sophisticated multivariate processes of our brain" (Battung, 1982, p. 6).

Gazzinga held similar view. "Clinical observation of this nature lead us to speculate that in normal man there may well exist a variety of separate memory banks, each inherently coherent, organized, and logical and with its own set of values. These memory banks do not necessarily communicate with one another inside the brain. If this is true, then the only way for the organism - which is to say, the cognitive subsystem in the forefront of consciousness at any one point in time, which is the verbal system in humans - to discover its total resources is to watch itself as it behaves" (1978, p. 134). Self-awareness may be a valid instructional objective, because it can help an individual discover conflicting emotions in order to become a more integrated person. Biofeedback may help a person become more self-aware by showing how one's heart rate and respiratory system reflects personal anxieties.

Just as research points to the validity of psychotechnology as an instructional technology, practice does as well. Many educators have reported extraordinary success in improving learner capabilities by using various psychotechnologies separately or in combination with each other. Georgi Lozanov's Suggestology Method, which includes rhythmic breathing, psychodrama and relaxation exercises, can ostensibly teach the equivalent of a two-year foreign language class in two months (Brain/Mind Bulletin Theme Pack, No. 11). Raymond Abrezol's Sophrology Method which utilizes focusing, breathing training, and mental rehearsal, apparently produced six Olympic Medal winners (Brain/Mind Bulletin Theme Pack no. 5).

Sheila Ostrander's book, Superlearning (1979), contains numerous reports of spectacular results when students were taught using these new approaches. Jean Cureau of the Lycee Voltaire reportedly achieved a ten to one speed-up in learning; students in a Naval Systems Class taught by the SALT Method (an adaptation of Lozanov's Suggestology Method) were said to learn at double speed. Dr. Donald Vannon claimed that he increased the percentage of A's in his class from 11 to 78 percent using relaxation techniques.

A host of other trainers, educators and psychologists have reported productive results from the use of the array of psychotechnologies which are rapidly becoming popularized. "Hendricks and Roberts (1977) listed over 1200 items in a bibliography on transpersonal/consciousness education ranging from esoteric religious education to biofeedback conditioning. While the results are almost uniformly good (in fact, some are amazing) . . . their anecdotal and descriptive natures indicate exciting and valuable contributions yet to be made by future educational researchers" (Roberts, 1980, p. 86).

Recent research suggests that we should look at the cognitive strategies a student uses if we want to understand how to significantly improve his ability to learn. Recent discussion of the progress of educational technology continues to emphasize that within the structure of formal education, the major variable in the learning process is the ability of the student (Bloom, 1976; Chadwich, 1979; Dillbeck, Aron & Dillbeck, 1979). Specifically, "The research indicates," said Carnegie Mellon psychologist, J. R. (Dick) Hayes, that "the differences in performance in the classroom that we observe are not so much a function of differences in I.Q. as they are differences in strategies for acquiring information" (Welles, 1983, p. 53). Gagne defined cognitive strategy as a "control process, an internal process by means of which learners select and modify their ways of attending, learning, remembering and thinking" (Gagne, 1979, p. 71). Gagne further stated "cognitive strategies have as their objects the learner's own thought processes" (p. 72).

Psychotechnologies are rapidly becoming popular practical methodologies among educators. A Stanford business course has used Zen, I-Ching, and Eastern relaxation techniques to promote creativity. An Iowa public school system has adapted Lozanov's Suggestology approach to teaching school children. Numerous other instructors have been and are, no doubt, using techniques that they have gleaned from such books as The Centering Book, The Moving Center, and Superlearning, in the classroom.

A glance at literature on classroom application of innovation teaching methods will reveal descriptions of a number of specific psychotechnologies such as meditation, biofeedback, and guided imagery with such cognitive strategies as memory, attention, creativity, and problem-solving ability.

As suggested earlier, much of what has been written about psychotechnologies has emphasized going beyond the ordinary to that which is currently extraordinary. Many have urged that an image of the future which is open to the extraordinary is crucial because it gives direction and momentum to latent possibilities (Battung, 1982; Houston, 1978). Lozanov (1976) introduced a process of "de-suggestion" in order to counteract the inhibiting influence of what is considered to be the norm. Walsh (1983) explained, "If our prevailing cultural and psychological models have underestimated what we are and what we can become, then perhaps we have set up a self-fulfilling, self-limiting prophecy. In such a case, the exploration of extreme psychological well-being, and the permeation of that knowledge in psychology and the larger culture, becomes a particularly important undertaking" (p. 10).

Thus, many see consciousness as a dominant future trend. In the preface to their college psychology textbook, authors Wallace and Fisher stated, ". . . we believe that the psychology of consciousness is in the midst of a zeitgeist, which we predict will continue through the 1980's and into the 1990's" (p. viii). Tom Roberts predicted the use of psychotechnologies as one of the future trends in education. "By the end of this decade any educator or social scientist who is unfamiliar with the research on biofeedback, meditation, psychedelic drugs, or imagery and relaxation will be as out of date as someone today who is ignorant of Freud's work with the unconscious, Skinner's operant conditioning, or Piaget's ideas of cognitive states (1983a, p. 71). In fact, an instructional technology textbook chapter titled "Future technologies of Instruction" predicted a shift from "technology as product" to "technology as process" (Heinich, p. 333).

Increasing interest and applications of psychotechnology put instructional technologists in an uncomfortable position. If, as preliminary evidence suggests, psychotechnologies get amazing results, then instructional technologists are not leaders, but laggards in what appears to be a promising trend. However, if the techniques prove to be less successful than forecast, then instructional technologists have failed to warn those practicing this instruction. In either case, instructional technologists do not seem to be well-informed about an issue which concerns our profession. We may be overlooking an emergent technology which many respected scientists and scholars believe can profoundly affect human capabilities. The titles of related books are indicative of that: *Superlearning*, *Supermind*, *No Limits to Learning*, *The Farther Reaches of Human Nature*, *The Possible Human*, and *Beyond Health and Normality: Explorations of Exceptional Well-Being*.

Instructional technologists are not actively exploring a technology which many scholars and educational practioners believe can profoundly affect human capabilities. While it is unthinkable in any profession to adopt a new technology without first examining the best evidence available regarding its potential, isn't it equally imprudent to dismiss a technology without first asking those same questions?

References

Alexander. T. (1983). The new technology of mind. *Fortune*, *107*(2), 82-89.

Barzakov, I. (1979). Optimalearning in self-instruction. *Barzakov Educational Institute Program*, (Workshop).

Battung, D. (1982). Implications of the brain mind revolution for education 1980-2000: A delphi pilot investigation of the comparative perspectives of selected brain researchers-disseminators and educators. *Dissertation Abstracts International*.

Bloom, B. *Human Characteristics and School Learning*. New York: McGraw-Hill, 1976.

Botkin, J. W., Elmandyra, M., and Malitza, M. (1979). *No Limits to Learning*. Oxford: Pergamon Press.

Brain/Mind Bulletin, Learning, education, creativity, Suggestology (theme pack no. 11). Los Angeles: *Brain/Mind Bulletin*, 1979-1981.

Brain/Mind Bulletin, Theories of mind and consciousness, physics, holographic theories (theme pack no. 5). *Brain/Mind Bulletin*, 1979-1981.

Brain/Mind Bulletin, Right/left hemispheric specialization (theme pack no. 8). Los Angeles: *Brain/Mind Bulletin*, 1977-1981.

Brown B. (1980). *Supermind: The Ultimate Energy*. New York: Bantam Books.

Capra, Fritjof. (1982). *The Turning Point*. New York: Bantam Books.

Chadwich, C. B. (1979). Why educational technology is failing (and what should be done to create success). *Educational Technology*. *19*(1), 7-19.

Dillbeck, M., Aron, A. and Dillbeck, S. (1979). The transcendental program as an educational technology: Research and applications. *Educational Technology*. *19*(6), 7-13.

Ferguson, M. (1980). *The Aquarian Conspiracy*. Boston: Houghton Mifflin.

Fletcher, J. (1978). Outer limits to human educability. *Education Researcher*. *7*(8), 13-18.

Gagne, R. M. and Briggs, L. J. (1979). Principles of Instructional Design. (2nd ed.) New York: Holt, Rinehart and Winston.

Gardner, H. (1983). Frames of Mind: A Theory of Multiple Intelligences. New York: Basic Books.

Gazzinga, M. S. and Le Doux, J. E. (1978). The Integrated Mind. New York: Plenum Press.

Harman, W. (1969). The new copernican revolution. Journal of Transpersonal Psychology. 1(2), 21-29.

Heinich, R., Molenda, M. and Russell J. (1982). Instructional Media. New York: John Wiley & Sons.

Hendricks, G. and Roberts, T. (1977). The Second Centering Book. Englewood Cliffs: Prentice-Hall.

Hendricks, G. and Wills, R. (1975). The Centering Book. Englewood Cliffs: Prentice-Hall.

Hendricks, G. and Hendricks, K. (1983). The Moving Center. Englewood Cliffs: Prentice-Hall.

Hilgard, E. R. (1980). Consciousness in psychology. Annual Review of Psychology, 31, 2-25.

Houston, J. and Masters, R. (1978). Listening to the Body. New York: Delacorte Press.

James, W. (1929). The Varieties of Religious Experiences. New York: Longmans, Green and Co.

Lozanov, G. (1976). Suggestology and Outlines of Suggestopedy. New York: Gordon & Breach.

Maslow, A. (1971). The Farther Reaches of Human Nature. New York: Plenguin Books.

Miller, J. (Ed.) (1983). States of Mind. New York: Pantheon Books.

Ostrander, F., Ostrander N. and Schroeder, L. (1979). Superlearning. New York: Dell.

Owen, S., Froman, R. and Moscow, H. (1981). Educational Psychology. (2nd Ed.) Boston: Little, Brown and Company.

Rappaport, B. (1975). Carnal knowledge: What the wisdom of the body has to offer psychotherapy. Journal of Humanistic Psychology. 15(1), 49-70.

Roberts, T. (Ed.) (1975). Four Psychologies Applied to Education. New York: John Wiley and Sons.

Roberts, T. (1981). Consciousness, psychology and education. Phoenix: Journal of Transpersonal Anthropology. 5(1), 79-116.

Roberts, T. (1983a). New Learning. In L. Grinspoon and J. Bakalar (Eds.), Psychedelic Reflections. New York: Human Sciences Press.

Roberts, T. (1983b). State of consciousness psychology and learning capacity. R. M. Smith (Ed.) Helping Adults Learn How to Learn: New Directions For Continuing Education. San Francisco: Jossey-Boss.

Robinson, D. W. (1977). The human potential movement. Phi Delta Kappa. 58(8), 636-638.

Schramm, W. (1977). Big Media, Little Media. Beverly Hills: Sage Publications.

Tart, C. (Ed.) (1969). Altered States of Consciousness. New York: Wiley.

Tart, C. (Ed.) (1983). Transpersonal Psychologies. El Cerrito, California: Psychological Processes.

Teich, A. H. (Ed.) (1981). Technology and Man's Future. (3rd Ed.) New York: St. Martin's Press.

Wallace, B. E. and Fisher, L. (1983). Consciousness and Behavior. Boston: Allyn and Bacon.

Walsh, R. and Shapiro, D. (Eds.) (1983). Beyond Health and Normality: Explorations of Exceptional Psychological Well-Being. New York: Van Nostrand Rheinhold Company.

Welles, C. (1983). Teaching the brain new tricks. Esquire. 99(3), 53.

Wilson, J., Robeck, M. and Michael, W. (1969). Psychological Foundations of Learning and Teaching. New York: McGraw-Hill Book Company.

Winn, W. (1984). Why media? Instructional Innovation. 29(2), 31-32.

Winner, Langdon (1977). Autonomous Technology: Technics-Out-Of Control As a Theme in Political Thought. Cambridge: MIT Press.

Wittrock, M. C. and Lumsdaine, A. A. (1977). Instructional psychology. Annual Review of Psychology. 28, 417-459.

The Role of Practice Versus Cueing
During Computer-Based Instruction

Michael J. Hannafin

Presented at the Annual Meeting of the Association for Education Communication and Technology, Atlanta, Georgia, March 1987.

ABSTRACT

The purpose of this research was to study the effects of cognitive and behavioral orienting activities and practice on student learning of cued and uncued information. The subjects were 54 ninth grade students: 28 males and 26 females. The instructional content for the study was based on the voyages and discoveries of spacecrafts. A significant difference was found between practiced versus non-practiced items, high versus low ability students, and for cued versus non-cued items. In addition, significant interactions were found between orienting activities and cueing, orienting activity and practice, and orienting activity-by-cueing-by-practice.

The Role of Practice Versus Cueing
During Computer-Based Instruction

The importance of practice during instruction has been emphasized by several researchers. Whereas practice per se appears to be of little inherent value (see, for example, Gagne', 1962; Dressel, Schmid & Kincaid, 1952), practice based upon explicit or general relationships with intended learning provides important support for learning. The early work of Thorndike (1931, 1932), for example, equated practice with reinforcement, suggesting that learning is systematically shaped through practice. For different reasons, contemporary cognitive theorists also support the value of practice during instruction. Both Anderson (1980) and Mayer (1978) have developed cognitive models which support the role of practice in reducing inhibition, improving responsiveness to related instruction, and enhancing retention.

The incorporation of pre-instructional orienting activities designed to heighten receptiveness to subsequent instruction has also been advocated (Hannafin & Hughes, 1986) . Advance organizers, a variation of cognitive orienting activity, are thought to provide cognitive anchoring mechanisms through which individuals assimilate instruction (Ausubel, 1979; Mayer, 1978), focus attention selectives (Derry, 1984), and alter the manner in which information is processed (Spiro, 1980). Explicit behavioral orienting activities are believed to aid intended learning of cued content but to the limit learning of incidental, uncued information (Duchastel & Brown, 1974; Kaplan & Simmons, 1974; Reynolds & Anderson, 1980). Activities that are integrative, requires greater integration of new with existing knowledge, often facilitate the learning of both cued and uncued lesson information (Glover, Bruning & Plake, 1982; Glover, Plake & Zimmer, 1983; Klauer, 1984). Whereas the effects of orienting activities in isolation have been supported (e.g., Mayer, 1979, 1984) contradictory findings have also been reported--particularly when the activities are employed in the presence of more powerful instructional variables (Barnes & Clawson, 1975; Hannafin, Phillips, Rieber & Garhart, 1986).

Whereas some design strategies may be effective when employed in isolation, their effects are often subsumed by other powerful techniques. Rarely have multiple instructional strategies been combined in an attempt to measure their relative value in a comprehensive instructional system. The purpose of this study was to examine the effects of orienting activities and practice on the learning of cued and uncued information presented via computer-based instruction. Main effects were predicted for orienting activities, cueing, and practice. Interactions, moderated principally by the enhanced power of practice, were also predicted.

METHODS

Subjects

The subjects were of 54 ninth grade students: 28 males and 26 females. All students were volunteers but were representative of typical ninth graders.

Materials

Instructional content. Instructional content was designed to be motivational, but unfamiliar to students. The lesson was based on material published by the National Aeronautics and Space Administration (1981) dealing with the Pioneer and Explorer spacecrafts that the outer reaches of the solar system. Technical material was reworded or clarified to be understood by typical ninth grade students.

The instruction was divided into six sections. Each section was devoted to a different aspect of spaceflight, and was introduced by related graphics in order to maintain student interest.

The instructional sequence began with a computer graphic depicting a spaceship launch. The next frame included an orienting activity which contained two cues related to the subsequent instructional segment. The cues were stated using either specific behavioral or integrative cognitive terms. An example of a behavioral and the corresponding cognitive orienting activity is shown in Figure 1.

INSERT FIGURE 1 ABOUT HERE

The average number of instructional frames per section was five, with individual sections consisting of four to seven frames.

Practice questions were then embedded at the conclusion of each section. The information related to one of the practice questions was cued initially by one of the orienting activities; the content of the other question was not cued during by the orienting activity. The questions were in multiple choice format, and contained one correct answer and three distractors. Upon entering the answer the student received immediate feedback either confirming a correct response or providing a correcting sentence informing the learner of the correct answer. The lesson was not repeated. Feedback back was only given related to the practice question. The amount of instruction was identical for all students.

The design of the lesson was based upon the software design model of Gagne', Wager, and Rojas (1981). Frame protocol was consistent so that a familiar computer displays were available during the instruction. All text was double spaced and the instructional material was broken into thematically related sections, separated by transitional graphic frames, to smooth the flow of the lesson and to minimize abrupt shifts in procedures.

Dependent Measures

A 28-item posttest related to the instruction was used to measure recall. Fourteen posttest questions were cued via the orienting activity; the other 14 questions were not cued. Seven of the cued items were practiced using parallel items during the lesson; the remaining cued items were not practiced. Of the 14 lesson items that were not cued, seven were practiced using parallel items during the lesson and seven were not practiced. This breakdown resulted in recall scores for four dependent measures: Cued and Practiced, Cued and Not Practiced, Not Cued but Practiced, and Not Cued and Not Practiced. The split-half reliability coefficient for the 28-item multiple choice posttest was .66.

Design

The study employed a completely crossed 2 x 2 between subjects design, with two additional factors crossed within subjects. The between-subjects experimental treatments included orienting activity (Behavioral, Cognitive) and ability (HI, LO). Students were classified as HI or LO in ability based on a median split of verbal intelligence estimate on the Iowa Test of Basic Skills (ITBS). The within-subjects factors included two levels of content cueing (Cued, Not Cued) and two levels of practice (Practiced, Not Practiced).

Procedures

Students were randomly assigned to an orienting activity group. At the outset of the lesson students were advised to study lesson frames carefully and were instructed in the procedural operation of both the lesson and computer. The students were also told that help could not be provided during the lesson except to pronounce unfamiliar words. During the lesson, student responses were stored for subsequent analysis.

Upon completion of the lesson, the posttest was administered immediately. The test was presented via computer, but no response feedback was provided. Again, student responses were evaluated for correctness and stored for subsequent analysis. Students were then instructed to signal the investigator that the lesson had been completed.

RESULTS

The means and standard deviations for each dependent measure are included in Table 1. The MANOVA source data are contained in Table 2.

INSERT TABLES 1 and 2 ABOUT HERE

Main Effects

Practice. A highly significant difference was found between the overall mean scores on practiced versus non-practiced information, F(1,50) = 234.62, p .0001. Practiced information was recalled at a much higher rate (mean = 12.79) than non-practiced information (mean = 8.69). Practice alone accounted for roughly 79% of the variance-accounted-for by treatments.

Cueing. A significant difference was detected between the overall mean scores for cued versus non-cued items F(1,50) = 12.82, p .005. More cued items were recalled (mean = 11.16) than non-cued items (mean = 10.22). Cueing accounted for approximately 4% of the sure variance.

Ability. As expected, a significant difference was also found between the overall mean scores obtained by Hi versus Lo students, F(1,50) = 9.36, p .005. High ability students recalled more factual information (mean = 22.84) than low ability students (mean = 20.13). Ability accounted for roughly 7% of the controlled sure variance.

Interactions

Orienting Activity by Cueing. A significant interaction was found between orienting activity and cueing, F(1,50) = 9.26, p .005. This interaction is illustrated in Figure 2. Cueing was most effective for the behavioral orienting activity while the remaining mean scores were comparable. The interaction accounted for roughly 3% of the overall treatment effects.

INSERT FIGURE 2 ABOUT HERE

Orienting Activity by Practice. A significant interaction was found between orienting activity and practice, $F(1,50) = 8.18$, p .01. This interaction is illustrated in Figure 3. Practice improved scores for both the behavioral and cognitive orienting strategy, but proportionately more for the cognitive strategy. Roughly 3% of the controlled variance was accounted for by this interaction.

Orienting Activity-by-Cueing-by-Practice. A significant three-way interaction illustrated in Figure 4, was also found. However, the magnitude of this effect was modest in comparative terms, $F(1,50) = 4.36$, p .05. This effect accounted for only 1% of the treatment variance. Both cueing and practice demonstrated an influence on the performance of the behavioral orienting activity group, but not the cognitive orienting activity group.

Overall, the design variables used in this study accounted for roughly 54% of the overall score variance. No other main effects or interactions were statistically significant.

INSERT FIGURE 3 AND FIGURE 4 ABOUT HERE

Discussion

The purpose of this study was to examine the effects of orienting activities and practice on the learning of cued and uncued information during computer-based instruction. The major findings indicated that practice was a significant component in isolation as well as in combination with other design variables.

Practice was by far the most powerful design component in the study. As a main effect, practice alone accounted for more than 79% of the observed score variance among the treatments. In a comparative sense, practice was far more powerful than the other design components used in this study, including both orienting activity and cueing. This is consistent with researchers who have advocated the inclusion of criterion-based practiced during instruction (Ausubel, 1978; Keller, 1982; Mayer, 1984). Practice appears to make explicit the intent of the lesson, providing the learner with an unambiguous aid for remembering. Practice also seems likely to strengthen relationships among practiced concepts, as well as practiced information with prior knowledge (Salisbury, Richard, & Klein, 1986).

Evidence for the power of practice was also reflected through the interaction between practice and orienting activity. The effect of practice was somewhat more effective the explicit behavioral than the more assimilative cognitive, orienting activities. This is evident in the uniform effect for practice across both orienting activities, but the superior performance of the behavioral group in the absence of practice. In effect, practice subsumed the effects attributable to the explicit orienting activity, and equalized the performance of both groups unspecified of orienting activity.

In the absence of practice, learning was more efficiently directed through the use of factually specific orienting devices than more abstract techniques. As students progressed through the lesson, they likely confirmed the relevance of the strategy, became more inclined to use the strategies provided, and built stronger associations among the activity provided, the factual nature of practice sessions (based on information that was practiced), and the eventual recall test. In effect, practice was important for both behavioral and cognitive groups, but most important for the cognitive orienting activity group.

Nearly 83% of the treatment score variation was accounted for by the combination of practice and practice-moderated interactions. This finding suggests that while other design features may result in statistically reliable effects, such effects either pale in the presence, or are enhanced differentially as a function, of practice. In this study, for example, the combination of practice and orienting activity yielded a significant interaction, while orienting activity alone was not a significant instructional component. Given the preponderance of earlier evidence suggesting significant effects for orienting activities such as advance organizers and behavioral objectives (e.g., Hamilton, 1985; Mayer, 1984; Melton, 1978), orienting activity effects might have been predicted in this study as well. However, when instructional components are combined into the integrated systems of typical computer-based instruction, the effects of such activities are often subsumed (Hannafin & Streisel, 1986). In effect, while orienting activities seem likely to exert influence in less powerful or poorly organized lessons (Mayer, 1979), they are less likely to be needed as the instruction is supported in a comprehensive lesson containing varied but powerful features such as practice.

A significant effect was also found for cueing as well as the cueing-by-orienting activity interaction. In general, cued items were recalled at a higher rate than uncued items. Most of this difference, however, was attributed to the influence of the behavioral activity on information cued through the strategy. The behavioral activity yielded the best performance for cued information; each of the remaining combinations yielded comparable performance. This is consistent with findings related to the relationship between orienting activity and practice (Koran & Koran, 1975; Melton, 1978; Reynolds & Anderson, 1982) which predicts most effective performance for information explicitly cued.

The cognitive activity, however, neither cued to specific criterion elements nor provided support to related lesson elements not cued. This is inconsistent with research where integrative activities were found to support the learning of both intended and incidental information (Klauer, 1984; Glover, Plake & Zimmer, 1983). In effect, a preparatory set was instilled via the cognitive activity which neither predisposed learners to particular lesson detail nor improved the learning of incidental information. Specific behavioral strategies, on the other hand, were most effective for the recall of strategy-specific (intended) learning but provided little support for learning strategy-irrelevant (incidental) lesson information.

The modest interaction among practice, orienting activity, and cueing suggests that practice and cueing are most influential under behavioral, and least influential for cognitive, orienting activities. The effects of practice and cueing were incremental for the behavioral orienting activity: Practice and cueing were most effective, followed by practice without cueing, cueing without practice, and no cueing and no practice. Neither practice nor cueing, however, were of significant impact for the cognitive orienting activity group. These results tentatively suggest that, for verbal information, behavioral strategies designed to focus explicitly on intended learning tend to yield the best outcomes when paired with relevant cueing and practice.

Several directions for further research are indicated. Cognitive orienting activities may be more important for higher-level learning than the verbal information assessed in the present study. To the extent that broader contextual learning is required, such as inferential or problem-solving learning, cognitive orienting activities are likely to be effective (Hannafin & Hughes, 1986). The effects of practice as a post-organizer of lesson information may not be as isolated for higher-level learning as for the learning of facts. Research designed to compare orienting activity effects across levels of learning will better define the generalizability of the present findings.

If, as proponents suggest, abstract orienting activities better enable learners to form relationships among lesson concepts as well as with prior knowledge (Ausubel, 1978; Mayer, 1984), practice might need to be examined as a between-subjects variable rather than as the within-subjects variable employed in this study. Practice seems likely to generalize when the nature of the practice is integrative in nature, such as required for higher-level learning. If so, "spread of activation" (Gagné, 1985) resulting from practice needs to be controlled between subjects.

Possible long-term retention differences resulting from the instructional manipulations used in this study, as well as the subsequent acquisition of related information, also require careful examination. Orienting activities that encourage greater depth of processing during encoding might be expected to yield greater retention of knowledge than those that do not. Efforts to establish the impact of orienting and processing activities in a more comprehensive framework should be advanced.

The present study confirmed the power of practice in the learning of verbal information, and supported the interactive effects among orienting activities, cueing, and practice. Whereas practice may exert a dominant influence among the lesson design components in the present study, it seems reasonable that more complex relationships among practice and related design variables will be identified. Future efforts to establish the effects of the various components of integrated CBI systems should prove valuable in prescribing a more comprehensive technology of lesson design.

References

Anderson, J.R. (1980). Cognitive psychology and its implications. San Francisco: Freeman.

Ausubel, D.P. (1978). Educational psychology, a cognitive view. New York; Holt, Rinehart, and Winston.

Barnes, B.R., & Clawson, E.V. (1975). Do advance organizers facilitate learning? Recommendations for further research based on an analysis of 32 studies. Review of Educational Research, 45, 637-659.

Derry, S.J. (1984). Effects of an organizer on memory for prose. Journal of Educational Psychology, 76, 98-107.

Dressel, P., Schmid, J., & Kincaid, G. (1952). The effect of writing frequency upon essay-type writing proficiency at the college level. Journal of Educational Research, 46, 285-293.

Duchastel, P.C., & Brown, B.R. (1974). Incidental and relevant learning with instructional objectives. Journal of Educational Psychology, 66, 481-485.

Gagne', E. (1985). The cognitive psychology of school learning. Boston: Little, Gromen & Co.

Gagne', R.M. (1962). Military training and principles of learning. American Psychologist, 17, 83-91.

Gagne', R.M., Wager, W.W., & Rojas, A. (1981). Planning and authoring computer-assisted instruction lessons. Educational Technology, 21, 17-26.

Garhart, C., & Hannafin, M.J. The accuracy of comprehension monitoring during computer-based instruction. Journal of Computer-Based Instruction (in press).

Glover, J.A., Bruning, R.H., & Plake, B.S. (1982). Distinctiveness of encoding and recall of text materials. Journal of Educational Psychology, 74, 522-534.

Glover, J.A., Plake, B.S., & Zimmer, J.W. (1983). Distinctiveness of encoding and memory for learning tasks. Journal of Educational Psychology, 74, 189-198.

Hamilton, R.J. (1985). A framework for the evaluation of the effectiveness of adjunct questions and objectives. Review of Educational Research, 55(1), 47-85.

Hannafin, M.J., & Streisel, A. (1986-February). The effects of orienting strategies and practice on the learning of cued and uncued information. Presented at the annual meeting of the Association for the Development of Computer-Based Instructional Systems, New Orleans.

Hannafin, M.J., & Hughes, C.W. (1986). A framework for incorporating orienting activities in computer-based interactive video. Instructional Science, (in press.)

Hannafin, M.J., Phillips, T.L., Rieber, L.P., & Garhart, C. (1986). The effects of orienting strategies and cognitive processing time on factual and inferential learning. Educational Communication and Technology Journal (in press).

Kaplan, R., & Simmons, F.G. (1974). Effects of instructional objectives used as orienting stimuli or as summary/review upon prose learning. Journal of Educational Psychology, 66, 614-622.

Keller, J.M., & Dodge, B. (1982). The ARCS model of motivational strategies for course designers and developers. Monroe, VA: Training Development Institute.

Klauer, K.J. (1984). Intentional and incidental learning with instructional texts: A Meta-analysis for 1970-1980. American Educational Research Journal, 21, 323-339.

Koran, M.L., & Koran, J.J. (1975). Interaction of learner aptitudes with question pacing in learning from prose. Journal of Educational Psychology, 67, 76-82.

Mayer, R.E. (1978). Advance organizers that compensate for the organization of text. Journal of Educational Psychology, 70, 880-886.

Mayer, R.E. (1979). Can advance organizers influence meaningful learning? Review of Educational Research, 49, 371-383.

Mayer, R.E. (1984). Aids to text comprehension. Educational Psychologist, 19, 30-42.

Melton, R.F. (1978). Resolution of conflicting claims concerning the effects of behavioral objectives on student learning. Review of Educational Research, 48, 291-302.

National Aeronautics and Space Administration. (1980). Pioneer, First to Jupiter, Saturn, and Beyond (NASA SP-446, Publication No. 328-155). Washington, DC: U.S. Government Printing Office.

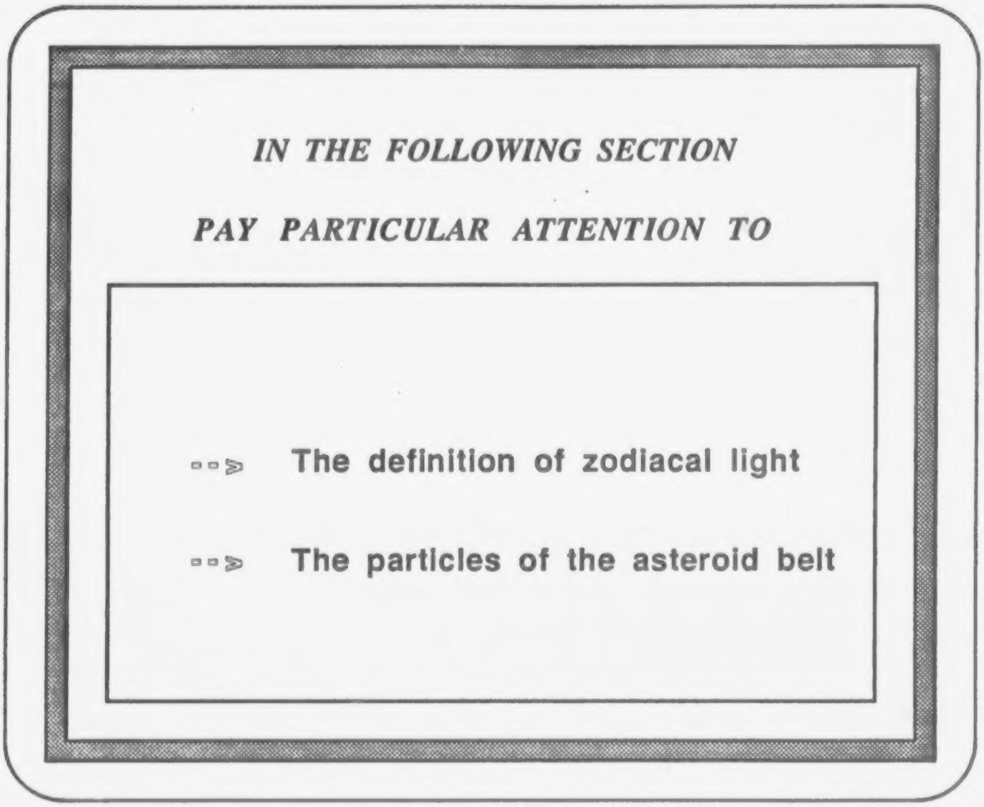
Reynolds, R., & Anderson, R.C. (1982). Influence of questions on the allocation of attention during reading. Journal of Educational Psychology, 74, 623-632.

Salisbury, D., Richard, B., & Klein, J. (1986). Prescriptions for the design of practice activities for learning: An integration from instructional design theories. Journal of Instructional Development.

Spiro, R.J. (1980). Constructive processes in prose comprehension and recall. In R.J. Spiro, B.C. Bruce, & W.F. Brewer (Eds.), Theoretical issues in reading comprehension. Hillsdale, New Jersey: Erlbaum.

Thorndike, E.L. (1931). Human learning. New York: Century.

Thorndike, E.L. (1932). The fundamentals of learning. New York: Columbia University, Teachers College.



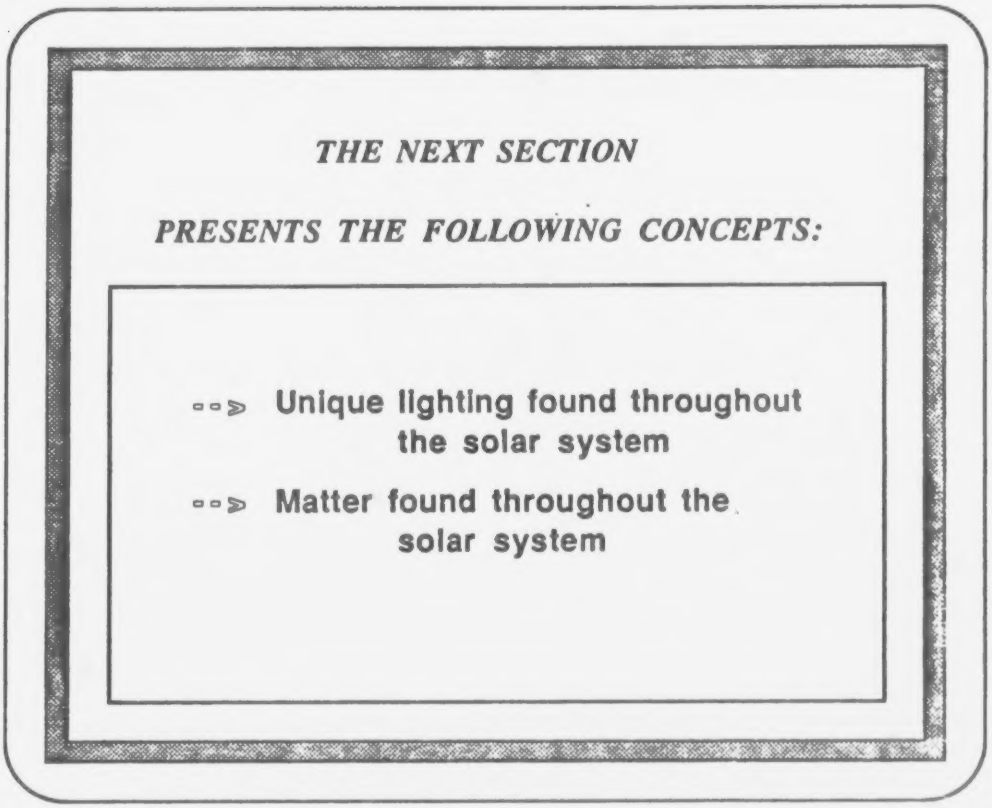
IN THE FOLLOWING SECTION

PAY PARTICULAR ATTENTION TO

▫▫> **The definition of zodiacal light**

▫▫> **The particles of the asteroid belt**

Figure 1. Sample Behavior and Cognitive Activities. (1 of 2)



THE NEXT SECTION

PRESENTS THE FOLLOWING CONCEPTS:

▫▫> **Unique lighting found throughout the solar system**

▫▫> **Matter found throughout the solar system**

Figure1: Sample Behavioral and Cognitive Activities. (2 of 2)

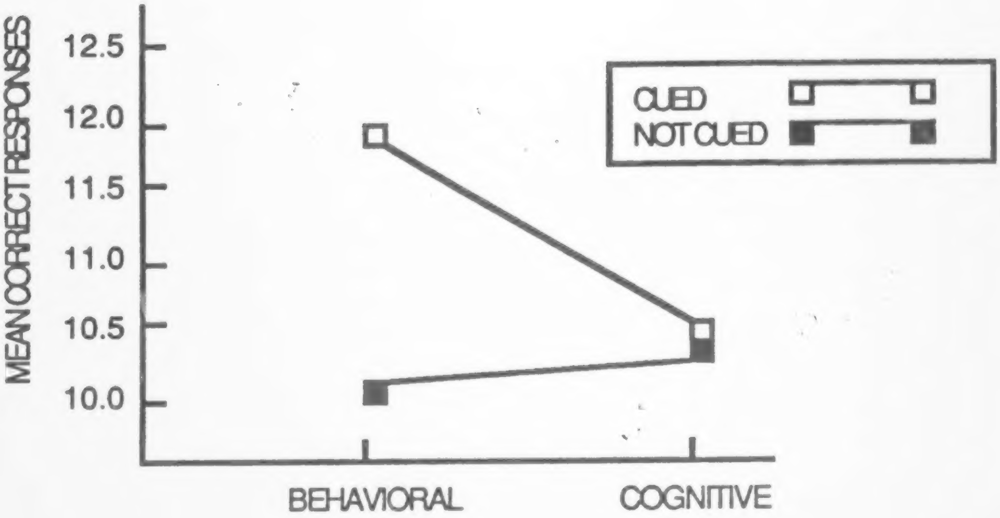


Figure 2. Interaction Between Orienting Activity and Cueing.

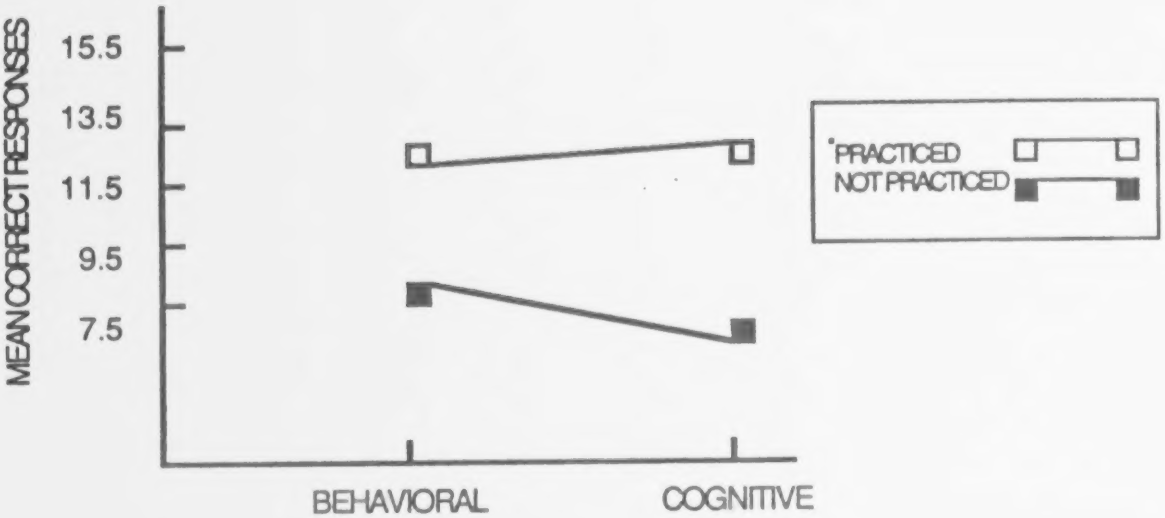


Figure 3. Interaction Between Orienting Activity and Practice.

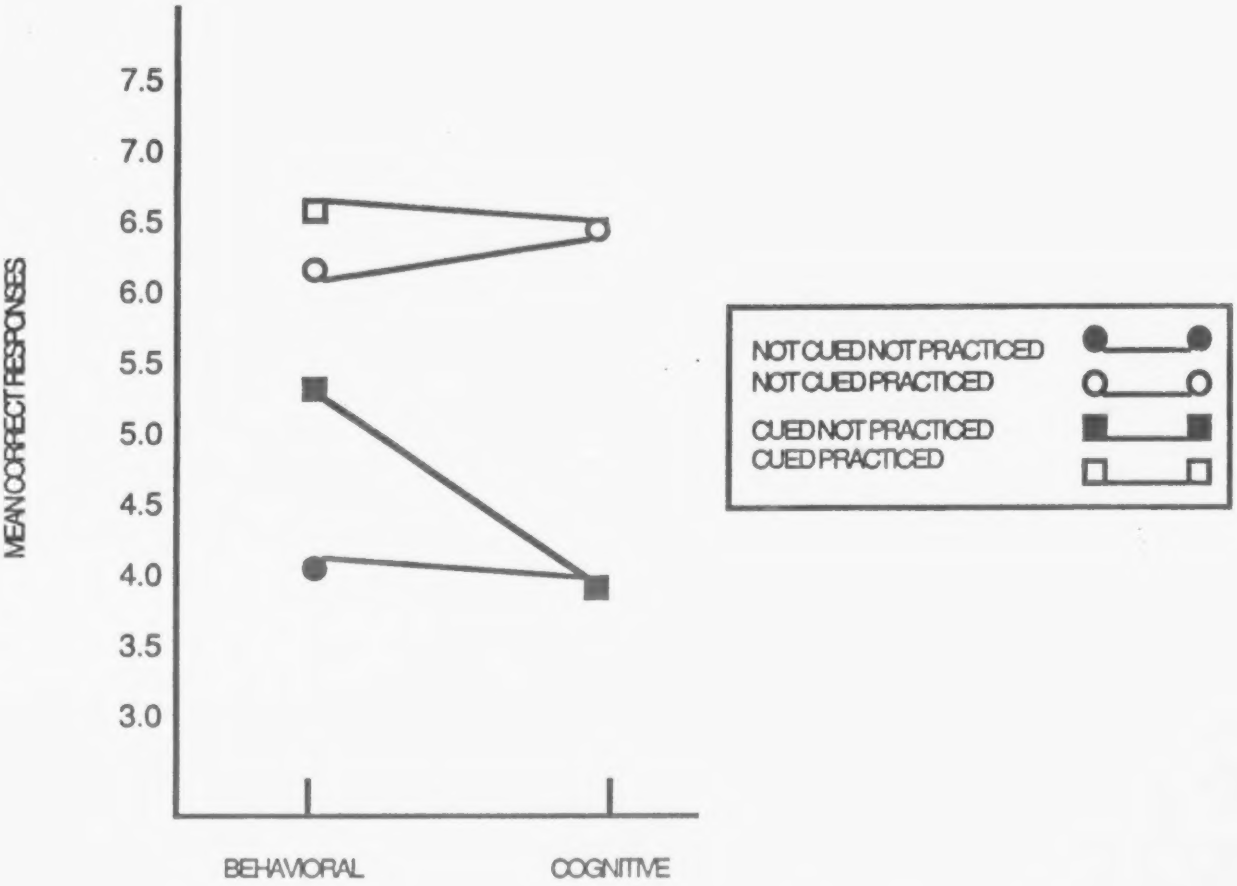


Figure 4. Interaction Among Orienting Activity, Cueing, and Practice.

THE EFFECTS OF LOCUS OF INSTRUCTIONAL CONTROL AND PRACTICE ON LEARNING FROM INTERACTIVE VIDEO

MICHAEL J. HANNAFIN
MARYANNE E. COLAMAIO

Presented at the Annual Meeting of the Association for Educational Communcation and Technology, Atlanta, Georgia, March 1987

ABSTRACT

The purpose of this study was to examine the effects of locus of instructional control and practice on the learning of facts, procedures, and problem solving skills during interactive video. Subjects were volunteers from graduate and advanced level undergraduate college classes. The instructional content was a 30 minute videotape, "Project Lifesaver," which was designed to introduce cardiopulmonary resuscitation (CPR). Students were randomly assigned to one of three instructional control groups: 1) designer imposed; 2) learner selected; or 3) linear (control). A posttest was administered to assess learning of facts, procedures, and problem-solving skills. The results indicated 1) significant differences between practiced and non-practiced information; 2) significant differences on posttest scores among locus of instructional control groups; and 3) a significant interaction between practice and type of learning.

The Effects of Locus of Instructional Control and Practice on Learning From Interactive Video

Interest in the instructional applications of interactive video has grown dramatically during the past decade (Cambre, 1984; Ebner, et al, 1981). Interactive video instruction has been described at various levels ranging from essentially uninterrupted linear video through fully conditional lesson execution where lesson sequence is controlled through the input of information external to the video itself (Daynes & Butler, 1984). For purposes of this paper, interactive video, is defined as "...any video program in which the sequence and selection of instructional messages is determined by the user's response to the material" (Floyd, 1982, p. 2).

Whereas interest in the application of interactive video has grown dramatically, only recently have empirical data has been published to either guide or support design decisions (Hannafin, et al., 1985). In general, findings related to the effects of interactive video instruction have been positive (see, for example, Ho, Savenye, & Haas, 1986; Hannafin, Phillips & Tripp, 1986; Malouf, MacArthur & Radin, 1986; Smith, Jones & Waugh, 1986). However, in other cases nominal or no performance effects have been reported (Dalton, 1986; Meanor & Hannafin, 1986). In addition, many of the methodological problems that plagued the study of instructional technology in the past have persisted in the study of interactive video (cf Clark, 1983; Reeves, 1986).

Some proponents have suggested that interactive video is a unique medium unlike either the video and computer component technologies (DeBloois, 1982). If true, then virtually no foundation exists upon which to base interactive video design decisions. However, the claims of unique effectiveness of any computerized instructional system have been challenged (Clark, 1985). A greater relationship among the evolved empirical research in the design of computer-based, video, and traditional instruction in the design of interaction video has been proposed (Hannafin, 1985). Significant research has been reported in a variety of areas which seems likely to generalize to the design of interactive video instruction. At the very least, accrued knowledge may represent a more logical framework for testing the tacit assumptions of interactive video than the simple acceptance of alleged uniqueness.

Considerable research in the design of computer-based instruction, for example, has focused on locus of instructional control decisions. Locus of instructional control can range from fully learner controlled through complete imposed lesson control. Proponents of learner control point to individualization, increased sense of responsibility for learning, and the potential for optimal learning efficiency as support for transferring control of lesson components and/or sequence to learners (Bunderson, 1974; Laurillard, 1984; Merrill, 1975; Merrill, Schneider & Fletcher, 1980).

Recently, however, research findings have contraindicated unaided learner control of lesson activities (Steinberg, 1977) in favor of either imposed adaptive lesson control or learner control with various forms of embedded coaching or advising (See, for example, Ross & Rakow, 1981; Tennyson, 1980, 1984; Tennyson, Christensen, & Park, 1984). Factors such as the nature of the learning task, the age of learners, and the desired learning outcomes of the instruction operate interactively during computer-based instruction (Hannafin, 1984).

The relationship between type of learning and type of learner interaction during computerized instruction has also been studied. Schaffer and Hannafin (1986), for example, reported increases in the magnitude of factual learning from interactive video, but corresponding decreases in the efficiency of such learning due to additional instructional time requirements. Some have suggested that interactive video is superior for higher-lever learning--especially in the health sciences field (DeChenne & Evans, 1982; Hon, 1982; Levensen, 1983; Lyons et al, 1982). Interactive video has been touted as an ideal system for the teaching of the higher-order problem solving skills required in medical emergency simulations (Harless, 1986). Others have suggested that the type, level, and location of interaction activities affects the magnitude and level of learning from interactive video. Explicit questioning during interactive video tends to improve the learning of factual knowledge but may hamper incidental, higher-level learning (Hannafin & Hughes, 1986). Precisely which types of interaction promote particular kinds of learning, however, remains unclear.

The purpose of this study was to examine the effects of varied interactive video lesson control options and of en-route lesson interactions on the learning of facts, procedures, and problem-solving skills.

METHODS

Subjects

Forty-eight subjects, consisting of graduate and advanced level undergraduate college students, participated in this study. None of participants had prior training in cardiopulmonary resuscitation (CPR) procedures, which were the focus of the instructional content of the interactive video lesson. In addition, none had prior experience in learning from interactive video.

Instructional Content

The instructional content used for the treatment phase of the study was the American Heart Association videotape, "Project Lifesaver." "Project Lifesaver" is a 30-minute videotape presentation which is designed to introduce CPR. The instructional content was selected due to the extensive use of interactive video in health sciences and the requirement for multiple types of learning required in the training of CPR (e.g., Bidwell, Collins-Nakai, Taylor & Jensen, 1985; Harless, 1986; Hon, 1982; Rosenblatt & Gaponoff, 1984)

The lesson was divided into four segments roughly equal in information density and duration: 1) "General Overview of the Heart Functions," 2) "Airway Problems and Techniques," 3) "Breathing Problems and Techniques," and 4) "Circulation Problems and Techniques." Each segment presented facts and procedural steps to be applied in problem-solving situations.

A total of 12 questions were embedded during the lesson. In order to provide en-route practice of lesson content, the questions were distributed equally among factual information, procedural steps, and problem-solving applications. One of each question type as embedded at the end of each of the four lesson segments.

Sample questions from the "Airway Problems and Techniques" segment are shown in Figure 1.

Insert Figure 1 About Here

Instructional Treatments

Three locus of instructional control versions of the lesson were developed: designer imposed, learner selected, and linear.

Designer Imposed. Students in this group followed a pre-determined path through the lesson. After answering each embedded question students were given knowledge of results of their response. At this point, they proceeded to the next segment if the answer was correct, or were branched to review only the video segment that related to the question if incorrect. After the review, the question was presented a second time. Again, knowledge of results was provided, and the lesson continued if the answer was correct. If incorrect on the second attempt, the correct response was provided before the lesson continued.

Learner Selected. Students in this group controlled their path through the lesson. At each point for which a designer imposed decision was enforced in the imposed control group, the student was permitted to make an individual control decision. In addition, students were permitted to choose the order of the video segments. Whereas students were advised as to the recommended lesson sequence, the actual selection of sequence choices was made individually. Students were given instructional control options after answering the embedded questions and given knowledge of results. If the answer was correct, the student was given the option to review only the video portion that pertained to the question or to proceed to the next part of the lesson; if incorrect, the same choice was provided. If the student chose to review the video segment, the option to repeat the question a second time was provided. If the student chose not to repeat the question, the lesson proceeded to the next part. If the question was chosen a second time and answered correctly, knowledge of results was provided and the lesson proceeded. If answered incorrectly on the second try, the correct response was provided and the lesson proceeded to the next part.

Linear (Control). Students followed a linear path through the lesson. After answering each of the embedded questions, students were given knowledge of results and proceeded to the next segment of the lesson. No options for controlling the sequence of the lesson, and no imposed decision for remediation or question repetition were provided.

CPR Posttest

The criterion test consisted of 24 randomly ordered multiple choice questions which tested for knowledge of the information and procedures, as well as problem-solving applications of the knowledge, presented during the lesson. The 12 embedded postsegment questions, distributed equally among facts, procedural steps, and problem-solving applications, were repeated on the posttest. In addition, 12 new questions were divided equally among facts, procedures, and problem-solving. Knowledge of results was not provided after individual posttest questions. Feedback in the form of total number of correct responses was provided upon completion of the posttest. Coefficient alpha for the 24-question multiple choice test was .61.

Dependent Measures

The dependent measures were scores on each of the posttest subscales: Facts, Procedures, and Problem-Solving. Separate scores were computed for each type of learning for practiced and non-practiced items for each type of learning. Practiced items were those embedded during the lesson; non practiced items were not presented, initially, but relevant instruction was presented during the lesson.

Design and Data Analysis

The study employed a 3 x 3 x 2 factorial design. One between subjects factor, Locus of Instructional Control, included three levels (Linear (Control), Designer Imposed, and Learner Selected). There were two within subjects factors: Test Scale which consisted of three levels (Facts, Procedures, and Problem-Solving), and Practice which consisted of two levels (Practiced and Not-Practiced).

MANOVA procedures were used to analyze the CPR posttest scores. Newman-Keuls contrast procedures, where appropriate, were used to examine pairwise differences.

Procedure

The 48 participants were randomly assigned to one of the three instructional control groups. The participants were introduced to the nature of the lesson but were told of neither their particular group assignment nor how their treatment differed from others.

All participants viewed the "Project Lifesaver" interactive video lesson in accordance with treatment group assignments. Upon completion of the lesson, the CPR Posttest was administered immediately.

All treatments were administered individually in a room designated for the study. The instructional treatments were systematically rotated to ensure balance across treatments and to avoid contamination of individual treatments over time.

Results

Table I contains the means and standard deviations for types of learning by treatment combinations. The findings are summarized by effect.

Insert Table I About Here

Locus of Instructional Control

Significant differences were found for the overall posttest scores among the three levels of instructional control, F (2,45) = 5.02, p .01. Both the Designer Imposed (x = 20.7) and the Learner Selected (x = 20.5) groups performed better than the Linear group (x = 18.4). No significant differences were found between the Designer Imposed and Learner Selected groups.

Practice

Significant differences were found between scores on practiced and non-practiced items, F (1,45) = 44.65, p .0001. Practiced items (x = 10.8) were learned at a significantly higher rate than non-practiced items (x = 9.0).

Type of Learning x Practice

There was a significant interaction between Type of Learning and Practice, F (2,44) = 30.74, p .0001. This effect is illustrated in Figure 2. Scores on practiced items were higher than non-practiced items for each type of learning, but the effects were proportionately greatest for factual learning and least influential for procedural learning.

Insert Figure 2 About Here

Discussion

The purpose of this study was to examine the effects of locus of instructional control and practice on the learning of facts, procedures, and problem solving skills from interactive video. The results suggest that either of the interactive versions of instruction was superior to the linear design, embedded practice exerts the most powerful influence among the treatment variables studied in learning from interactive video, and that the influence of practice is greatest for factual and problem-solving learning.

The differences found for locus of instructional control were interesting. Both of the interactive lessons were superior to the linear video lesson. This finding is consistent with findings for computer-based instruction which suggest that adaptive designs, with sequence options either imposed by the designer or learner control with coaching for making choices, yield successful learning (See, for example, Ross & Rakow, 1981; Tennyson, 1984).

Practice, as defined in this study, was important for the learning of facts and problem-solving skills, but relatively unimportant for the learning of procedures. This effect is consistent with the hypotheses of early television researchers. For procedural tasks, visual images are important aids in that they illustrate for the learner the succession of steps to be followed (Chu & Schramm, 1967). In effect, a form of vicarious rehearsal may occur during which appropriate visually-oriented procedures can be modeled and consequences observed. Video images may provide sufficiently strong instructional stimuli to illustrate visual procedures, and to encourage appropriate mental rehearsal, that physical practice in the procedures themselves is unnecessary in some cases (See also Heestand, 1978, Allen, 1957; Fitts & Posner, 1967).

Problem-solving, on the other hand, was more sensitive to the influence of formal practice during interactive video instruction. Though the required procedures may be fairly well known, the selection and application of such steps to novel situations during controlled instruction is uniquely important. These findings offer support for the growing interest in interactive video simulations (Floyd 1982, Harless, 1986; Hon, 1983; Levensen, 1983) where the practice and application of problem solving skills principal learning focus.

The impact of interaction during video lessons -- the opportunity to respond and receive feedback and appropriate remediation or clarification — also provides support for some of the promise of interactive video. The findings of this study are consistent with previous research in which progressive interaction improved learning from video in a more or less linear manner: The more interactive instruction the greater the learning of factual information (Schaffer & Hannafin, 1986). The present findings replicate, extend, and qualify this conclusion. This study replicated the effects using verbal information derived from an entirely different content and tentatively extended earlier conclusions to include problem-solving. The effects, however, were not evident for procedural learning, thereby qualifying the scope of the inference. Based on both earlier research and the present study, interactive video instruction appears useful and effective for certain types of learning, but is likely unnecessary or even ineffective for others.

A predicted interaction between practice and locus of instructional control was not found. Practice was hypothesized as most important for the learner selected group since the inherent sequence provided through imposed lesson control assured the remediation of mislearned information, the repetition of questions missed initially, and the provision of correct answers when needed. In the learner selected treatment, the implementation of these features was controlled directly by individuals permitting students to select when (or if) options would be utilized. It was presumed that appropriate practice and feedback would be most important for this group since individuals could use information derived during practice to self-regulate, modify subsequent decisions, and otherwise alter the manner in which choices were made (Salisbury, Richard & Klein, 1986). An inspection of the "path" followed by students in the learner selected treatment, however, revealed that only one of the 16 participants followed a lesson completion path other than the one "advised" initially. In effect, the operational differences between the designer and learner control groups were virtually eliminated during the study.

The findings of this study provide additional support for the effectiveness of interactive forms of video instruction. Based on the few research studies reported to date, there is reason to be encouraged with the performance of interactive video. The study of interactive video, however, remains in its infancy. Whether the context for study is to be extrapolated from related research or a new research context is to be proposed to examine the presumed unique capabilities of the technology, disciplined inquiry in the study of interactive video is imperative. The need for further study remains before the promise of the technology can be validated.

REFERENCES

Allen, W. H. (1957). Research on film use: Student participation. Audio Visual Communication Review, 5(2), 423-450.

Bidwell, C. M., Collins-Nakai, R. L., Taylor, M. B., & Jensen, W. (1985). Multidisciplinary team production of computer-based simulation to teach pediatrics. Journal of Medical Education, 60(5), 397-403.

Bunderson, C.V. (1974). The design and production of learner controlled courseware for TICCIT system: A progress report. International Journal of Man-Machine Studies, 6, 479-491.

Cambre, M. A. (1984). Interactive video. Instructional Innovator, 29(6), 24-25.

Chu, G. C. & Schramm, W. (1967). Learning from television: What the research says. Washington: National Association of Educational Broadcaster.

Clark, R. (1983). Reconsidering research on learning from media. Review of Educational Research, 53, 445-459.

Clark, R. (1985). Evidence for confounding in computer-based instruction studies. Analyzing the meta-analyses. Education Communications and Technology Journal, 33, 249-262.

Dalton, D. W. (1986). The efficiency of computer-assisted video instruction on rule learning and attitudes. Journal of Computer-Based Instruction, in press.

Daynes, R., & Butler, B. (1984). The videodisc book: A guide and directory. New York: John Wiley & Sons.

DeBloois, M. L. (1982). Principles for designing interactive videodisc instructional materials. In M. L. DeBloois (Ed.), Videodisc/microcomputer courseware design. Englewood Cliffs, NJ: Educational Technology Publications.

DeChenne, J. A. & Evans, R. (1982). Simulating medical emergencies. Instructional Innovator, 27(1), 23.

Ebner, D. G., Manning, D. T., Brooks, F. R., Mahoney, J. V., Lippert, H. T., & Blason, P.M. (1984). Videodiscs can improve instructional efficiency. Instructional Innovator, 29(6), 26-28.

Fitts, P. M., & Posner, M. I. (1967). Human performance. Monterey, CA: Brookes Cole.

Floyd, S. M. (1982) Thinking interactively. In S. M. Floyd & B. Floyd (Ed.) Handbook of interactive video. White Plains, NY: Knowledge Industry Publications.

Hannafin, M. J. (1984). Guidelines for using locus of instructional control in the design of computer-assisted instruction. Journal of Instructional Development, 7(3), 6-10.

Hannafin, M. J. (1985). Examining the empirical assumptions of computer-based interactive video. Educational Communication and Technology Journal, 33, 235-247.

Hannafin, M. J., Garhart, C., Rieber, L., & Phillips, T. L. (1985). Keeping interactive video in perspective: Tentative guidelines and cautions in the design of interactive video. In E. Miller and M. Mosley (Eds.), Educational media and technology yearbook. Denver: Libraries Unlimited.

Hannafin, M. J., & Hughes, C. (1986). A framework for incorporating orienting activities in computer based interactive video. Instructional Science, in press.

Hannafin, M. J., Phillips, T. L., & Tripp, S. D. (1986). The effects of orienting activities, rehearsal, and processing time during interactive video. Journal of Computer-Based Instruction, in press.

Harless, W. G. (1986). The application of exams during interactive video: The case of Frank Hall. Journal of Computer-Based Instruction, in press.

Heestand, D. (1978). The use of inserted questions in videotape programs. International Journal of Instructional Media, 7(2), 149-157.

Ho, C. P., Savenye, W., & Haas, N. (1986). The effects of orienting objectives and review on learning from interactive video. Journal of Computer-Based Instruction, in press.

Hon, D. (1982). Interactive training in cardiopulmonary resuscitation. Byte, 7(6), 108-138.

Hon, D. (1983). The promise of interactive video. Performance & Instruction Journal, 22(9), 21-23.

Laurillard, D. M. (1984). Interactive video and the control of learning. Educational Technology, 24(6), 7-15.

Levenson, P.M. (1983). Interactive video: a new dimension in health education. Health Education, 14(6), 36-38.

Lyons, C., Krasnowski, J., Greenstein, A., Maloney, D., & Tatarczuk, J. (1982). Interactive computerized patient education. Heart & Lung, II(4), 340-341.

Malouf, D. B., MacArthur, C. A., & Radin, S. (1986). Using interactive videotape-based instruction to teach on-the-job social skills to handicapped adolescents. Journal of Computer-Based Instruction, in press.

Meanor, P., & Hannafin, M. J. (1986). The relationship between lesson familiarity and interactive video instruction. Submitted for publication.

Merrill, M. D., (1975). Learner control: Beyond aptitude-treatment interactions. Audio-Visual Communications Review, 23(2), 217-226.

Merrill, M. D., Schneider, E. W., & Fletcher, K. A. (1980). TICCIT. New Jersey: Educational Technology Publications.

Reeves, T. (1986). Research and evaluation models for the study of interactive video. Journal of Computer-Based Instruction, in press.

Rosenblatt, A. A., & Gaponoff, M. (1984). The microcomputer as a vehicle for continuing medical education. Journal of Family Practice, 18, 629-632.

Ross, S.M., & Rakow, E. A. (1981). Learner control versus program control as adaptive strategies for selection of instructional support on math rules. Journal of Educational Psychology, 73(5), 745-753.

Salisbury, D., Richard, B. & Klein, J. (1986). Designing practice: A review of prescriptions and recommendations from instructional design theories. Journal of Instructional Development, 8(4), 9-19.

Schaffer, L. C. & Hannafin, M. J. (1986). The effects of progressively enriched interactivity on learning from interactive video. Educational Communication and Technology Journal, in press.

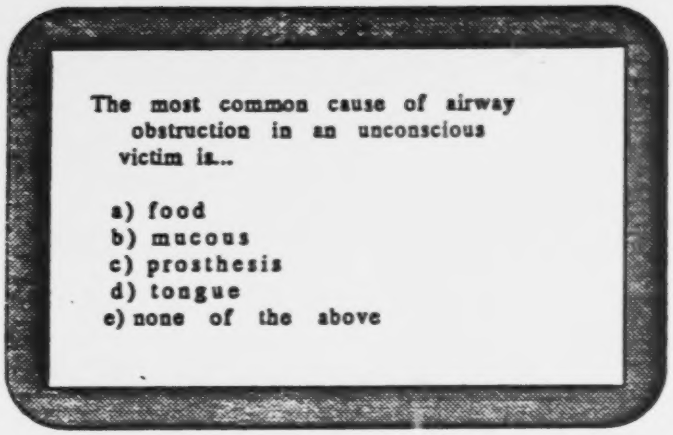
Smith, S. G., Jones, L. L., & Waugh, M. L. (1986). The effects of interactive video on laboratory and pre-laboratory chemistry instruction. Journal of Computer-Based Instruction, in press.

Steinberg, E. (1977). Review of student control in computer-assisted instruction. Journal of Computer-Based Instruction, 3, 84-90.

Tennyson, R. D. (1980). Instructional control strategies and content structure as design variables in concept acquisition using computer-based instruction. Journal of Educational Psychology, 72(4), 525-532.

Tennyson, R. D. (1984). Artificial intelligence methods in computer-based instructional design: The Minnesota Adaptive Instructional System. Journal of Instructional Development, (3), 17-22.

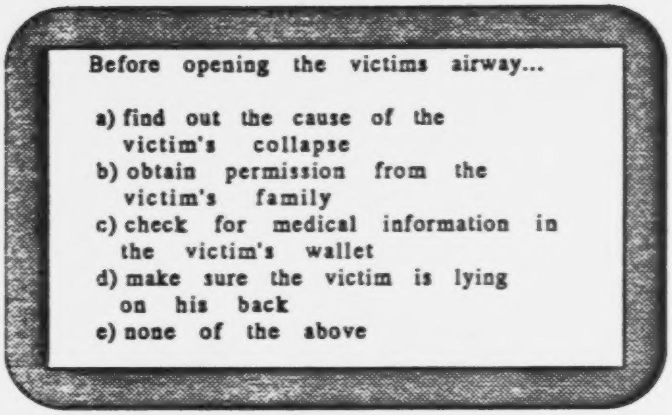
Tennyson, R. D. Christensen, D. L., & Park, S. I. (1984). The Minnesota Adaptive Instructional System: An Intelligent CBI System. Journal of Computer-Based Instruction, 11, 2-13.



The most common cause of airway obstruction in an unconscious victim is...

a) food
b) mucous
c) prosthesis
d) tongue
e) none of the above

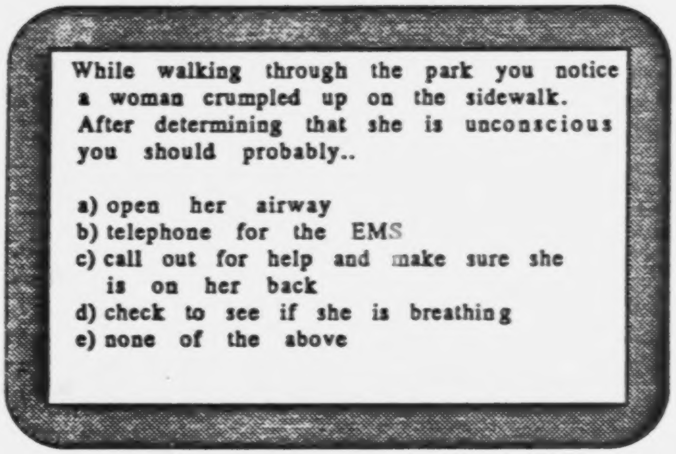
Sample Factual Question



Before opening the victims airway...

a) find out the cause of the victim's collapse
b) obtain permission from the victim's family
c) check for medical information in the victim's wallet
d) make sure the victim is lying on his back
e) none of the above

Sample Procedural Question



While walking through the park you notice a woman crumpled up on the sidewalk. After determining that she is unconscious you should probably..

a) open her airway
b) telephone for the EMS
c) call out for help and make sure she is on her back
d) check to see if she is breathing
e) none of the above

Sample Problem Solving Question

Figure 1. Sample Practice Questions from CPR Lesson.

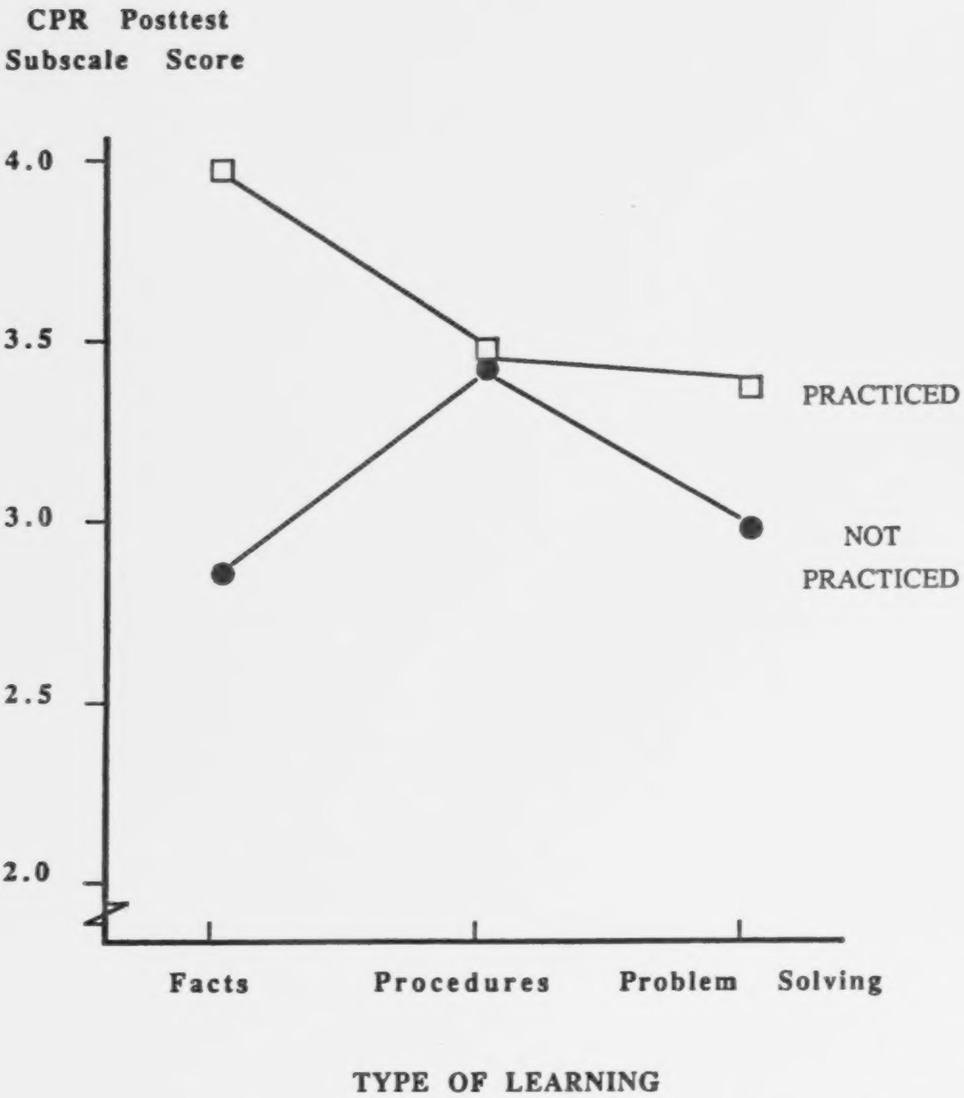


Figure 2. Interaction between Practice and Type of Learning.

Queueing Theory:
An Alternative Approach To Educational Research

Sarah H. Huyvaert
Department of Teacher Education
Eastern Michigan University

Running head: QUEUEING THEORY

Abstract

Queueing theory is used to study wait and congestion within a system and, through the study of these visible phenomena, to discover malfunctions within the system that are otherwise transparent. After reviewing the theory and its application in areas other than education, a cursory review of the litearture dealing with time-on-task, teacher burnout, student grouping, and classroom discipline was used to demonstrate that queues are prevelant in educational systems. It was concluded that queueing theory could be a viable tool of inquiry for the educational researcher.

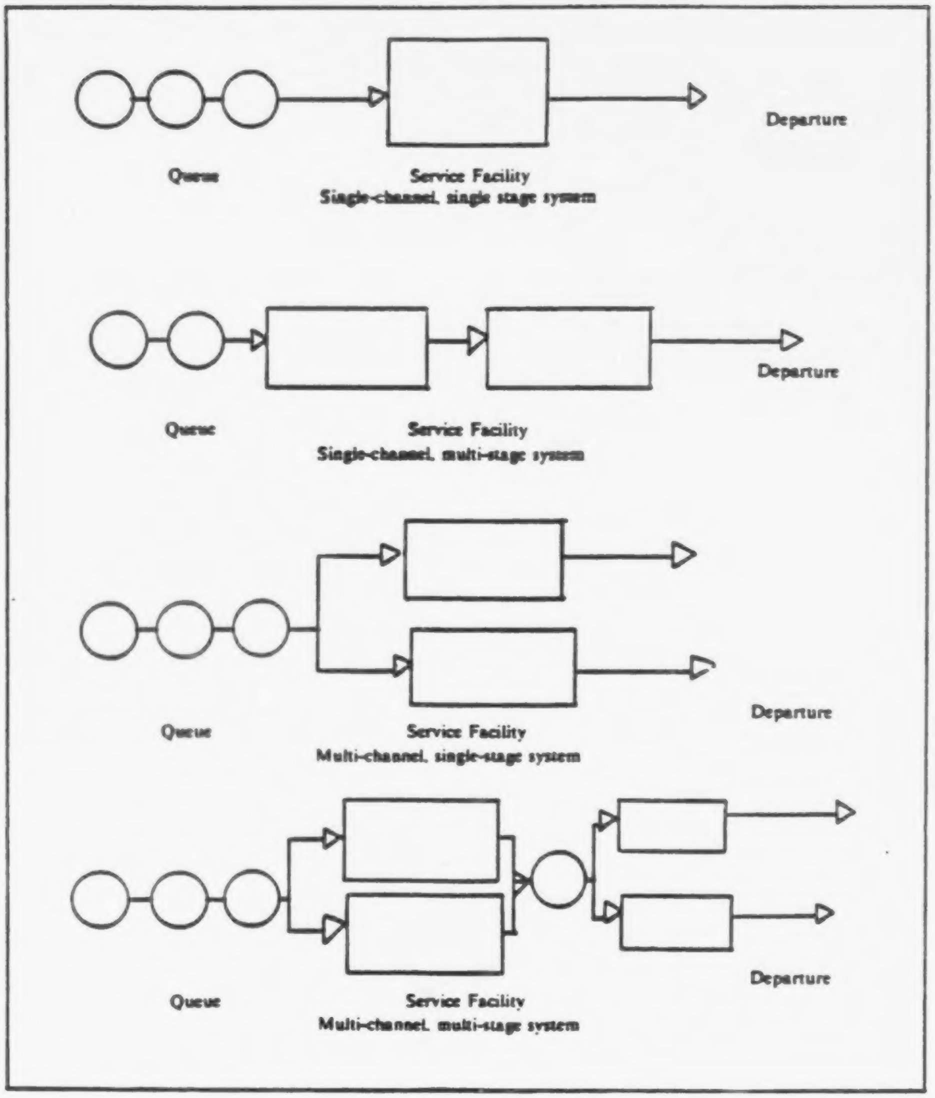
Queueing theory is a form of operations research that uses mathematical formulas and/or computer simulation to study wait and congestion within a system. The purpose of the theory is to study the queues that result from such congestion and, through the study of these visible phenomena, discover malfunctions within the system that are transparent to the decision maker. Although queueing theory was originally applied to telephone trafficking problems, today it is being adopted by many different fields and adapted to their needs. Queueing theory has been proven to be effective in almost all areas of business and formal courses on the subject are being taught in most Colleges of Business. Computer science and industrial engineering apply queueing theory daily and case studies have been conducted in music, library science, social psychology, and in the health fields (Giffin, 1978; Gross & Harris, 1974; Murdoch, 1978; Newell, 1971; Panico, 1969 and Saaty, 1961).

Although many of the problems that have been analyzed through the use of the theory are analogous to problems in education, the field of education is conspicuous by its absence from the list of applications. In addition, most educational systems are so complicated that in-depth understanding of how they operate can only be accomplished through formal system analysis procedures such as queueing theory.

The purpose of this study, therefore, was to examine queueing theory to determine if the theory could be applied in an educational setting. It was determined at the onset of the study that the theory would be untenable in education if: (1) the basic assumptions of the theory can not be met in an educational setting; (2) the theory is designed to analyze a particular class of queues and these queues are non-existent in education; (3) queueing problems in education are so insignificant as to warrant no formal investigation; or (4) the tools and techniques used in the theory are inappropriate for educational research.

Significance of the Study

This study should be of special interest to the educational technologist who seeks to find solutions to practical problems and thereby improve the practice of education because "anyone who hopes to improve an organization needs first to understand it, and understanding is the chief legacy of inquiry (Willower, 1977 p. 79). Therefore, the significance of the study lies not in the mere creation of a model or the testing of a theory, but rather in the prospect that a new tool of inquiry, queueing theory, may be introduced to the


Queue
Service Facility
Departure
Single-channel, single stage system
Queue
Service Facility
Departure
Single-channel, multi-stage system
Queue
Service Facility
Departure
Multi-channel, single-stage system
Queue
Service Facility
Departure
Multi-channel, multi-stage system

educational community. For, as noted by Getzel, (1977) "new instruments and techniques of observation and analysis play a role not only in the solving of problems but also in raising questions which might otherwise never have been thought of" (p. 18). As new questions are raised, and the answers to the questions are sought, new insight into, and an understanding of, the problems will be gained.

Introduction to Queueing Theory

Queueing theory is used to study wait and congestion within a system. Wait occurs whenever a unit must wait for service and if more than one unit is forced to wait congestion results. The problem of congestion increases proportionally with the randomness of arrivals and the variation of service times. The queues that result from this congestion are often symptomatic of other, more severe, system problems including problems with staffing, scheduling, and/or material allocation.

Queueing Structures

The basic structure of a queueing system is defined in terms of the number of service channels and the number of service stages. Although queueing diagrams almost always depict queues in a linear fashion, it is not necessary that the units "line-up" for service. Anytime a unit is waiting for service, it is in a queue. Figure 1 presents the four most common queueing structures.

---

insert figure 1 about here

The first structure in Figure 1 (single-channel, single stage), is the simplest of all queueing systems. In such a system, there is only one server and consequently only one line is formed. The second structure (single-channel, multi-stage) is one in which there is only one line, but the unit must pass through several stages before service is complete. In the next queueing structure (multi-channel, single-stage), there are several lines but the unit must pass through only one stage. The final diagram represents a system in which there is more than one stage and there are several servers at each stage (multi-channel, multi-stage).

Characteristics of Queueing Systems

According to queueing theory, there are six major components of a queueing system that may determine the way in which a queue is formed.

1. Arrival pattern: average number of arrivals per unit of time (e.g., the average number of students that need the teacher's individual attention during one class period).

2. Service pattern: average time required to service a unit (e.g., the average amount of time it takes to complete an instructional packet).

3. Queue discipline: manner by which units are selected for service;
   FIFO -- first in, first out
   LIFO -- last in, first out
   SIRO -- service in random order
   PRIO -- service by priority

4. Number of service channels: number of parallel service stations that can service units simultaneously (e.g., number of IBM computers in an instructional lab).

5. Number of service stages: number of stages a unit must proceed through before the service procedure is completed (e.g., checking in with lab attendant, doing work at computer, checking out with lab attendant).

6. System capacity: The number of units allowed in the system at any one time (e.g., number of students allowed to enroll in a graduate class).

Basic Assumptions of the Theory

Queueing theory can only be applied to systems in which the following assumptions are met:

1. both arrival rates and/or service rates involve a degree of uncertainty or randomness - if this were not true, each event could be scheduled to the exact moment and there would never be a queue;
2. average service rate is greater than average arrival rate - if this assumption is not met, then there would always be a queue;
3. the probability distribution of both arrival and service rates can be determined.

These assumptions can be met in instructional settings. Assumptions one and two can be proven by simple observational data. For instance, it is easily observable that students complete assignments at varying rates and even the best of instructors cannot predict with 100% accuracy the exact moment when the students will complete their assignment. Observational data will also support assumption number two. For example, if the server is a learning lab and that lab is idle at least some portion of the day, then assumption two has been met. Assumption three is not as easily verifiable because the appropriate database currently does not exist in education. It is, however, reasonable to assume that such data can be collected because much of the current work being done in educational research is based on similar statistical data.

Application of Queueing Theory

Table 1 displays the number of queueing theory application abstracts that were published by OR/MS from January, 1961 through January, 1985. OR/MS is a publication of Executive Science, Inc. which each month abstracts articles that have appeared in current publications.

Insert Table 1 about here

Table 2 presents an array of the type of system problems that have been studied through the use of queueing theory and provides examples of corresponding problems in educational systems. The table is in no way comprehensive but is intended to portray the wide variety of problems that can be studied through the use of the theory.

Insert Table 2 about here

Educational Issues

None of the 214 studies presented in Table 1 addressed an educational problem and a search of the ERIC database failed to uncover any queueing studies that were conducted in education. However, many of the problems that have been addressed through the use of the theory (Table 2) are analogous to problems in education. Is it possible that queueing problems in education ar so insignificant as to warrant no formal analysis? In order to answer this question, current educational issues were examined to determine if some of the recursive problems in the field can be defined more precisely through the use of queueing analysis.

Time-on-Task

Over the last several decades, researchers increasingly have directed their attention toward the use of time in education. (For a review of this literature see for example, Anderson, 1984; Karweit, 1983; Walberg & Frederick, 1983; Wiley & Harnischfeger, 1974). From

Area of Study	1961-65	1966-70	1971-75	1976-80	1981-85	TOTALS
Inventory Management	7	1	2		1	11
Personnel Selection	1	1				2
Quality Control		1	1			2
Production Scheduling	12	6	5	4	2	29
Plant Layout	1	1				2
Procurement of Raw Materials	1		1			2
Maintenance	1	2	3	5	5	16
Service Trades				1	1	2
Government Service			2	4	4	10
Office Management	1	4	2	3	4	14
Transportation	17	10	21	6	2	56
Communication	5	3	1	3	2	14
Facilities Replacement	2					2
Public Health	4	1	3	8	6	22
Research and Development	1		1	1		3
Manufacturing	3					3
Materials Handling	1	4				5
Miscellaneous	10	3		5	1	19
TOTALS	67	37	42	40	28	214

Author	Purpose of Study	Analogous Problems in Education
Shaunty & Hare (1960)	to compute to number of spare parts to keep on hand at each field station	computing the number of consumable books needed in an individualized lab
Maxwell (1965)	to study problems of best inventory size and the best production sequence	determining the number of learning stations needed and the best sequence of learning stations
Nelson (1967)	to study production systems that are constrained by limited labor resources and limited machine resources	individualizing a program that is constrained by a limited number of learning resources
King (1970)	to determine the optimum crew size required to reduce wait-time	determining the optimum number of aids or volunteer tutors needed to reduce student wait-time
Graff (1971)	to apply queueing theory in the decision for investment in additional resources	determining the need for investing in additional Audio/visual equipment
Gaver Strinvansan (1972)	to optimize corporate research and capabilities in the production of new products	optimizing formative evaluation and development capabilities in the production of new products
Leigh (1974)	to explore relationships between available resources and workloads	exploring relationships between number of free computers in a lab and the workload of the students

Author	Purpose of Study	Analogous Problems in Education
Rosseau & LaPorte (1977)	to minimize the patients' total queueing time at an outpatient clinic where patients require a variety of services	minimizing students' time off-task that is caused by wait-time
Styles & Cox (1977)	to assist management in attaining a balance between different activities in pharmaceutical research	attaining a balance between different instructional design and development activities
Gross & Pinkus (1979)	to design a support system for items	developing a support system for repairable AV equipment using outside resources
Albright (1980)	to describe optimal control of operation and repair of a fleet	obtaining control of operation and repair of AV equipment
Ament (1980)	to classify customers and tellers according to degree of difficulty in transactions and set up two queues accordingly	classifying students by the type of problems and the amount of time they require for help
Elsayed (1981)	to compare two repair policies, one with priority for a particular mode of failure and the other without	comparing different types of help sessions in which students with certain kinds of problems receive priority in obtaining help
Scott & Hailey (1981)	to study the utilization of cardiac telemetry units in a hospital; to analyze the costs and benefits of adding units	utilizing resources in a learning lab and determining when new units should be added

Carroll's Model of School Learning (1963), to the Beginning Teacher Evaluation Study (BTES) work done in the mid-1970's, and on through the effective school research of today, it has been shown repeatedly that there is a positive relationship between time-on-task and learning. One of the major findings from the time-on-task research was that a surprisingly large amount of time during the school day is spent in non-instructional activities. Rossmiller (1983) has calculated the amount of time that the average student spends on task during a school year of 1080 hours to be approximately 364 hours. Burns (1984) found that, on the average, only 75% of the elementary school day is actually spent in the classroom and 37% of that time is spent on non-instructional activities. Karweit and Slavin (1981) have observed that:

> To increase achievement from a score of 3.4 grade equivalent to 3.8 would require a daily increase of 13 minutes of active learning time. This increase, from 37 to 50 minutes, would require either a sizeable increase in scheduled time or tremendous improvements in classroom efficiency....realizing significant gains in learning time would have to come from recovering lost minutes due to interruptions, waiting, and classroom transitions. (p. 171)

Previous time-on-task studies have focused on such variables as day length, the amount of time that is allocated to each subject, how time is actually spent in the classroom, and how much time students spend on-task (Stallings, 1980). These studies have been successful in showing a relationship between time and learning, but they have shed little light on how to improve educational practice. The researchers have been able to identify some of the ways that non-instructional time is used. Among these are time that is spent in: waiting for help from the instructor; making a transition from one activity to another; and, acquiring and returning instructional materials. Such activities usurp as much as 25% of the instructional time (Thurlow, Graden, Ysseldyke & Algozzine, 1984; Anderson, 1984; Karweit, 1984).

Waiting for help is, by definition, a queueing problem and queueing theory certainly can provide the structured, systematic approach that is needed. In addition, by examining studies that have been done outside of the field of education, it can be seen that queueing theory can likewise be employed to analyze wait and congestion problems that result from transitions from one activity to another or from the acquisition of materials. The solutions to such problems may well rest in alternative approaches to resource allocation, staffing, scheduling, and/or instructional methods and queueing theory can provide valuable insight into the study of these alternative approaches.

Student Grouping Patterns

It is possible that the amount of time that students in a particular classroom spend in waiting or in transistion from one activity to another is influenced by the characteristics of the individuals within the class. Everston (1982), in comparing classrooms composed of high-ability students with those composed of lower-ability students, found that the lower-ability classes required a great deal more individualized help from the teacher than did the higher-ability group. According to Everston, "multiple individual demands for help from the teacher meant that more students had to wait a considerable time before getting help" (p. 342). While the students were waiting for that help, they were essentially placed in a queue.

Beckerman and Good (1981) conducted a similar study that compared favorable classrooms (less than 1/3 of students were lower-ability students) with unfavorable classrooms (more than 1/3 of the students were lower-ability). They found that "teachers in a more favorable classroom have more time to provide individual help to low-ability students, because there are fewer demands on teachers" (p. 324). At the same time, Everston, Sanford and Emmer (1981) found that students in extremely heterogeneous classes spent more time off task than students in other classroom organizational patterns.

Although these findings are not surprising, they do reinforce the idea that the way children are grouped in a classroom affects the amount of the time that individual children spend waiting for help and this in turn could affect their level of academic achievement. Unfortunately, little research has been done on how student grouping affects such outcomes (Beckerman and Good, 1981). Queueing theory can be used to compare how different classroom organizational patterns influence the amount of time that a student will spend waiting.

Teacher Burn Out

The literature on teacher burnout often focuses on helping the teacher cope with stressors that exist within the educational setting (Bardo, 1979; Hendrickson, 1979; Kyriacous & Sutcliffe, 1979). The most frequently mentioned solutions for burnout are concerned with helping teachers deal with their own emotions, rather than being concerned with the elimination of the source of the problem. McNeely (1983) has noted that the literature on burnout "often treats as a constant the organizational environment within which the burned out are employed. In short, remedies consistent with this level of conceptualization obviously favor attention on the individual as the agent of personal change" (p. 84). The same literature that emphasizes coping strategies also identifies lack of time to grade papers, lack of time for individual student needs, and lack of adequate books, materials and equipment as being the major causes of stress in the teaching profession (Cook & Leffingwell, 1982; Needle, Griffin, Svendsen, & Berney, 1980; Weiskopf, 1980). Each of these stress causes results in queues forming - queues of papers waiting to be graded and queues of students waiting for books, materials and/or equipment. Given the current database, it is difficult, if not impossible, to determine if the shortage of teacher time is due to poor organization or due to over-utilization of the teacher as a resource and yet it is necessary to identify the source of the problem before viable solutions can be found. Queueing theory certainly can help in this process because the theory is used to analyze both resource utilization and queueing problems that result from poor system organization.

Classroom Discipline

There are many causes of discipline problems within a classroom but student wait-time is one of the leading contributors to the problem (Doyle, 1985; Everston, 1982; Kounin, 1970). Wait-time often results in behavioral problems as described by Everston (1982):

> At one point, five students were at the teacher's desk, and most of them were waiting for help ... Having so many students in such close proximity to each other frequently created problems and led to the misbehavior. (p. 349)

The phrase "waiting for help" indicates that a queue has formed and strongly suggests that the situation would be especially amenable to queueing analysis. The diminution of discipline problems is especially important in light of the findings from the time-on-task research for as Seifert and Beck (1984) have noted:

> Each incident of discipline reduces the number of minutes of engaged learning time from two to four minutes, depending upon the seriousness of the discipline problem. Each time the teacher stops the

> engaged learning process to discipline a student the entire class is placed in an off-task mode. (p. 30)

Summary of Educational Issues

Many currrent educational problems that have been identified in the literature do contain queueing elements and four of the more general educational issues were chosen for examination in this paper. In each of the four cases it was shown that traditional research methods have added to the educational knowledge base but have done little to suggest how the practitioner can implement the findings. The research methods that were used in many of the studies were designed to aid in conclusion-oriented research, not in decision-oriented research. In addition, each study was designed to examine only one aspect of the system. Through the use of queueing theory, it is possible to examine several areas simultaneously. For instance, the phenomenon of discipline, or misbehavior, manifests itself in all four areas that were examined, but it manifests itself in different ways. In the area of time-on-task, discipline problems can detract from the total engagement time of the entire class and thus reduce the time-on-task. At the same time, students vary in the amount of individual help they require from the teacher and because of this, the ratio of high-ability students to low-ability students will affect the amount of time that students must wait for help. Wait-time in turn is directly proportional to the number of discipline problems and the more discipline problems, the more time the students will spend-off task. In addition, excessive discipline problems can, and do, add to teacher stress and hence indirectly to teacher burnout.

The intertwining that is apparent between each of these areas can be traced to elements of wait or congestion within the system. Because all educational systems are complex systems, such intertwining and interrelatedness are not surprising. Changes that ameliorate malfunctions in one area of the system often will result in undesirable changes in other areas of the system. A research method that is versatile enough to examine each component independently or to examine all the components simultaneously could add valuable insight into the functioning of the system and could aid in system related decision-making. Queueing theory is just such a method.

Tools and Techniques

The properties that are common to all queues were outlined earlier and even though the identification of the properties is an important first step in the understanding of a queuing problem, a more in-depth understanding can only result from a systematic examination of the queue. The two methods that are used in the systematic study of queues are mathematical analysis and computer simulation. Both methods involve the construction of queueing models - models that are designed to replicate both the system and the interaction of the major components within the system. The use of models: (1) facilitates the description and comprehension of a system; (2) reveals hidden relationships between various components of the system; (3) helps to determine the kinds of data that need to be collected; (4) allows the system to be viewed in its entirety by examining all of the variables simultaneously; and (5) makes it possible to enlarge the system of interest in a step-wise fashion (Vazsonyi, 1963).

One of the major advantages of using models is that they allow the decision maker to experiment on a replica of the system rather than on the system itself. This is especially important in education where: (1) the manipulation of the variables to be studied may prove to be disruptive to the system; (2) it is often difficult to deal with all of the possible alternative solutions in one experiment; and, (3) it is often difficult to isolate the effect of one variable from the effects of other variables.

Mathematical Models

Mathematical, or analytical, models use mathematical formulas and equations to show the relationships among various elements in the system. In a queueing model, the parameters are defined in terms of average arrival rate and average service rate or in terms of average time between arrivals and average service time. The variables include queue length, time spent in the queue, and server utilization. The constants can include such things as the number of parallel servers and/or the number of service stages.

The selection of the proper mathematical formulas to be used in the solution of an analytical model is based on the characteristics of the queueing system. Figure 2 gives the formulas for the simplest of all queues - queues with only one channel and with little fluctuation in either service or arrival patterns.

		$\lambda/M/1$	$\lambda/M/5$
Mean arrival rate		λ	λ
Mean interarrival time		$1/\lambda$	$1/\lambda$
Mean service rate		μ	$M\mu$
Mean service time		$1/\mu$	$1/M\mu$
Expected number in system	(L)	$\frac{p}{1-p}$	$\frac{\lambda}{\mu} + \frac{(\frac{\lambda}{\mu})^M \lambda\mu Po}{(M-1)!\ (\mu M-\lambda)^2}$
Expected number in cueue	(-0)	$\frac{2^2}{1-0}$	$\frac{(\frac{\lambda}{\mu})^M \lambda\mu Po}{(M-1)!\ (\mu M-\lambda)^2}$
Mean time in system	(W)	$\frac{L}{\lambda}$	$\frac{1}{\mu} + \frac{(\frac{\lambda}{\mu})^M \mu Po}{(M-1)!\ (\mu M-\lambda)^2}$
Mean time in cueue	(wo)	$\frac{Lo}{\lambda}$	$\frac{\lambda^2}{\mu(\mu-\lambda)}$
Server utilization	p	λ/μ	$\lambda/M\mu$
Probability of cueue	P_o	p^2	
Probability of no units in system	P_o	1-o	$\frac{1}{\sum_{n=0}^{M-1} \frac{1}{n!}(\frac{\lambda}{\mu})^n + (\frac{\lambda}{\mu})^M \frac{1}{M!\ (1-p_m)}}$

insert_Figure_2_about_here

The purpose of the hypothetical problem that follows is to show how queueing theory might be used in the investigation of one fairly common educational problem.

Educational Example: A study conducted by a local school district revealed that the district owned more educational films per student than did any other district within the state. At the same time, teachers within the district used proportionally fewer films than did teachers in the surrounding districts. An analysis of the situation revealed that six teachers shared in the use of one projector, that it was used on the average of 12 times a week, and that it was often unavailable when teachers wanted to use it. The teachers picked up the projector at the beginning of a period and returned it during their break which meant that the teachers would hold the machine for an average of two hours. It takes 30 minutes, on the average, to show a film and the machine remains idle for the remaining 1 1/2 hours.

Following the preliminary analysis, two alternative solutions to the problem were suggested. The curriculum council recommended the purchase of six additional projectors. The media director, whose budget would be affected most directly by the purchase, suggested that, in lieu of buying new machines, the school could use a student to deliver the machines to the classroom when needed and to retrieve them after each viewing session. Everyone agreed that this would be the less expensive of the two alternatives, not everyone agreed that the teachers' needs would be met by such a solution.

A queueing analysis would begin by examining each of the altenatives and extracting the pertinent data about each as shown in the chart below.

	Plan_1 Status Quo	Plan_2 With Additional Machines	Plan_3 With Student Attendant
Number of teachers	6	3	6
Number of films shown	12	6	12
Length of film	30	30	30
Number of minutes machine held	120	120	60

After the data have been extracted, a mathematical model of each of the plans would be designed. Data from Plan I will be used to demonstrate how the analyst would compute the basic queueing statistics that would be used to compare the alternatives.

The average arrival rate is 12 - the average number of films shown in a one-week period. Although it takes only 30 minutes to show a film, it is necessary to model the entire time the teacher retains the projector - 120 minutes. Because the school week is 30 hours long (5 days x 6 hours), the service rate is equal to 15 units per week. Based on this information, all other queueing statistics for Plan I are calculated as follows:

p = Percent of time the projectors are busy
= 12/15 = .80 utilization rate

P_q = Probability that teachers are waiting
= $.80^2$ = .64

L_q = Expected number of teachers waiting
= .64/.20 = 3.2 teachers waiting

W_q = Average time a teacher must wait before receiving a projector
= 3.2/12 = .266 x 30 hours = 7.98 hours

P_0 = Probability of no waiting
= 1-.80 = .20

Similar calculations were performed for each of the alternative approaches and the resulting statistics are presented below.

			P	L_q	P_0	W_q
Plan 1	12	15	0.8	3.2	0.2	0.266 (7.98 hrs)
Plan 2	6	15	0.4	0.266	0.6	0.044 (1.32 hrs)
Plan 3	12	30	0.4	0.266	0.6	0.022 (0.66 hrs)

An examination of these data from the queueing analysis reveals that plans 2 and 3 are almost identical and that both plans are superior to the status quo. Surprisingly, plans 2 and 3 vary in only one area -- expected wait-time. The amount of time a teacher can expect to wait for a projector is twice as long in plan 2 than in plan 3 and this demonstrates the complexity of queueing situations. The service rate is accountable for this difference and because this rate is used to calculate several of the intervening statistics, it has a compounding effect on both the formation of the queue and upon the corresponding amount of time spent in waiting.

Although this situation is hypothetical, it is not an uncommon one in education. In many cases where similar decisions must be made, the decisions are based on purely financial considerations or on the power base of the groups presenting the alternatives. An immediate benefit that derives from a queueing analysis is that the frame of reference for the decision maker can be shifted from a subjective one of "I think" or "I feel" to a much more objective one of "I can show" or "I can demonstrate".

Computer Simulation

Because of the complexity of many queueing systems, mathematical formulas often become unwieldy for all but the most sophisticated of mathematicians. As the number of interactions increases, the task of analyzing the effects of the interactions becomes more and more formidable and computer simulation becomes an indispensable tool.

Blake (1979) defines simulation as "the establishment of a mathematical-logical model of a system and the experimental manipulation of that model on a digital computer" (p. 3). Because simulation combines a logical model with a mathematical model, it tempers many of the constraints that are inherent in mathematical analysis and allows for more freedom in the construction of system models (Gordon, 1969). This easing of constraints makes it possible to study systems that were intractable with the use of mathematical analysis.

Model Formulation: In a computer simulation, a queueing system is defined in terms of entities, attributes, sets, and activities. Entities are the objects of interest within the system. The entities are used to model the progression of units through the system. Each entity has a number of characteristics that may or may not be unique to that entity. These characteristics, or attributes, guide a unit through the system. The attributes that an entity possesses are determined by the modeler and may include such characteristics as: the time that the entity entered the system; the type of service it is to receive; and the sequence in which it is to receive the service. A set is a group of entities that share the same attributes. It is not necessary, however, that the attributes for each member of the set contain the same value. For instance, one member of the set may enter the system at 1:10 and the next member enter the system at 1:29. Both members contain the attribute "time system was entered", but the value of the attribute is different for each one. Activities include all of the processes, or service stages, through which an entity must pass before leaving the system.

Data Preparation: There are basically three kinds of data that can be used in computer simulations: (1) real data, obtained from a total population; (2) sampling data that are obtained from a representational sample of the population; or (3) theoretical data, a combination of sampling-data and computer generated data.

Programming Languages: Although simulations can be run using general-purpose languages, the time required for program preparation generally can be reduced by using a special-purpose simulation language. Typically, such languages include: (1) a routine that schedules the events in simulated time; (2) random number generators; (3) routines that control the probability generator; (4) automatic calculation of statistical data; and (5) flexible report generators. (Davis & McKeown, 1984).

Access to a simulation language should pose no problem to the educational researcher. There are several languages that can be run on the more powerful microcomputers and most major universities have at least one mainframe version of a simulation language.

Conclusion and Recommendations for Future Research

As a result of this study it was found that: (1) the basic assumptions of queueing theory can be met in educational systems; (2) education does experience the types of problems that are typically analyzed through the use of the theory; (3) wait and congestion problems do exist in education and they contribute to other, more serious problems in the field; and, (4) the tools and techniques, including mathematical analysis and computer simulation, are appropriate for educational research.

Both the literature on queueing theory and the literature on educational issues suggests that there are an unlimited number of queueing problems in a service industry as large as the educational system. In addition, every educator with whom the author discussed the theory was able to identify queues within their own system. This leads to the conclusion that there is an unlimited number of educational areas that can benefit from queueing analysis. Listed below are examples of some specific areas that would lend themselves to queueing analysis:

... exploring relationships between the number of free computers in a lab and the workload of students;
... attaining a balance between different instructional design and development activities;

... optimizing formative evaluation and development capabilities in the production of new products;
... determining the need for investing in additional audio/visual equipment;
... determining the optimum number of volunteer tutors needed to reduce student wait-time;
... individualizing a program that is constrained by a limited number of learning resources;
... determining the number of learning stations needed and the best sequence of learning stations;
... computing the number of books resources needed in an individualized lab.

Before the theory can be applied, however, it must be tested in actual educational environments to determine if there is some hidden reason why the theory will not work. Naturalistic studies should be undertaken to add to the educator's basic understanding of where lines and bottlenecks actually occur. Techniques must be developed that will aid in the accurate collection of data. Only after the theory has been proven to be effective can it be used as a decision-oriented research tool in education. At every stage of theory adoption and adaption, a concerted effort should be made to see that queueing theory studies are published in leading educational journals. Even if the studies are site-specific, undertaken solely for the purpose of answering specific questions about specific systems, the findings must be published if the field of education is to make the most efficacious use of the theory.

References

Anderson, L. (Ed.). (1984). Time and school learning: Theory, research and practice. New York: St. Martin's Press.

Beckerman, T., & Good, T. (1981). The classroom ratio of high- and low-aptitude students and its effect on achievement. American Educational Research Journal, 18(3), 317-327.

Brown, D. (1979). Modelling the use of the manager's time. OMEGA - The International Journal of Management Science, 7(1), 55-60.

Cook, J., & Leffingwell, R. (1982). Stressors and remediation techniques for special educators. Exceptional Children, 49(1), 54-59.

Cooley, W. (1983). Improving the performance of an educational system. Educational Researcher, 12(6), 4-12.

Everston, C.M. (1982). Differences in instaructional activities in higher- and lower-achieving junior high English and math classes. The Elementary School Journal, 82,(4), 329-350.

Everston, C., & Emmer, E. (1981). Effective management at the beginning of the school year in junior high classes. Journal of Educational Psychology, 74(4), 485-98.

Graham, J. B. (1985). Serious about keeping good teachers? Help them reclaim lost teaching time. The American School Board Journal, 172(1), 35-36.

Getzel, J. (1977). Problem-finding and research in educational administration. In G. Immegart & W. Boyd (Eds.), Problem Finding in Educational Administration, (pp. 5-22). Lexington, MA: Lexington Books.

Giffin, W. C. (1978). Queueing: Basic theory and applications. Columbus, OH: Grid Inc.

Hendrickson, B. (1979). Teacher burnount: How to recognize it: What to do about it. Learning, 7(5), 37-39.

Karweit, N. (1984). Time-on-task reconsidered; synthesis of research on time and learning. Educational Leadership, 41(8), 32-35.

Karweit, N., & Slavin, R. E. (1981). Measurement and modeling choices in studies of time and learning. American Educational Research Journal, 18(2), 151-171.

Kornbluth, M., & Little, D. (1976). The nature of computer simulation modeling. Technological Forecasting and Social Change, 9, 3-26.

McNeely, R. (1983). Organizational patterns, work and burnout in the public school. Urban Education, 18(1), 82-97.

Panico, J. A. (1969). Queueing theory : A study of waiting lines for business, economics and science. Englewood Cliffs, NJ: Prentice-Hall, Inc.

Rossmiller, R. (1983). Time-on task: A look at what erodes time for instruction. NASSP Bulletin, 67(465), 45-49.

Russel, E.C. (1983). Building simulation models with SIMSCRIPT II.5. Los Angles, CA: CACI, Inc.

Saaty, T. L. (1961). Elements of queueing theory with applications. New York: Dover Publications, Inc.

Vazsonyi, A. (1963). The advantages of mathematical models. In A. Shuchman (Ed.), Scientific Decision Making in Business, (pp. 94-95). New York: Holt, Rhinehart and Winston, Inc.

Walberg, H., & Frederick, W. (1983). Instructional time and learning. In H. Mitzel (Ed.), Encyclopedia of Educational Research, (pp. 917-924). New York: Free Press.

Weiskoph, P. (1980). Burnout among teachers of exceptional children. Exceptional Children, 47(1), 18-23.

Willower, D. (1977). Some issues in research on school organizations. In G. Immegart & F. Wilecki (Eds.), An Introduction to Systems for the Educational Administrator (pp. 41-62). Reading, MA: Addison-Wesley Publishing Co.

Implications of an Attention Reduction Training (ART) Model for Education and Technology

John W. Jacobs
Department of Psychology

John V. Dempsey
Center for Educational Technology

and

David F. Salisbury
Department of Educational Research

Florida State University
Tallahassee, Florida 32306

Paper presented as part of the Fourth Annual Open Forum on the Foundational Issues of the Field (Research and Theory Division) at the annual meeting of the Association for Educational and Communications Technology, February 25 - March 1, 1987.

Running Head: ATTENTION REDUCTION TRAINING

Abstract

Recent research in automaticity training suggests that attentional resources related to certain intellectual skills can be engineered and this type training facilitates later transfer of learning. One potentially useful attention reduction training technique involves requiring learners to respond to two tasks simultaneously. Since primary task variables can be manipulated with concomitant increases or decreases in secondary task (i.e., the task of interest) performance, it is suggested that automaticity be viewed as being continuous rather than discrete in nature. The technology for applying this dual task technique to electronics training is discussed. The basic procedure involves training an underlying (subordinate) skill of recognizing several common electrical components (e.g., resistor, battery, diode, etc.) in order to investigate subsequent learning on a superordinate task (i.e., recognizing simple circuits within larger schematic configurations). It is pointed out that several training issues need to be empirically tested before the feasibility of attention reduction training (ART) using the dual task procedure can be judged useful for educational applications.

Introduction

The purpose of this paper is to present a computer-based attention reduction model of training and outline important issues that must be addressed before the model can be incorporated into an educational setting. The rationale for developing this model comes from current research and theory related to metacognition; specifically, aspects of metacognition related to executive control activities such as planning, checking, and monitoring. As a result of these activities, the executive controller is hypothesized to regulate and orchestrate other, subordinate mental processes (see e.g., Wagner & Sternberg, in press). In theory, executive control activities interact with and compete for attentional space with these subordinate processes (Brown & Campione, 1979). Thus, training aimed at decreasing attentional capacity related to performance of one or more relevant subordinate processes may serve to increase attentional resources for (superordinate) executive processes.

Our model of attention reduction training (ART) is based on an assessment procedure developed by researchers in the area of memory (see e.g., Britton, Piha, Davis, & Wehausen, 1978; Eysenck & Eysenck, 1979; Tyler, Hertel, McCallum, & Ellis, 1979). This procedure is referred to as the dual task technique. The dual task technique involves having subjects respond to two tasks simultaneously. This task, as originally employed, was used to assess the amount of attentional resources consumed when performing memory-related tasks, such as semantic verses structural encoding of verbal stimuli. Subsequent research has, in some cases, not supported the use of this task as a valid assessment tool in this way due to incomplete or inaccurate accounting of methodological assumptions thought to underlie the dual task technique (see e.g., Fisk, Derrick, & Schneider, 1982). These assumptions will be described in detail in the next section. Despite these potential problems, we believe that this assessment tool may be a potential alternative as a training device, given that (a) both tasks are computer-based, thus allowing close and accurate monitoring of critical performance components of each task, and (b) an independent assessment of automatic processing be employed. One such measure is vocalization latency, which is currently being used for studying automatic processing of critical prerequisite skills in reading (e.g., Stanovich, Cunningham, & Feeman, 1984a, 1984b; see also Cohen, 1987 for a review of automatic processing measures used in reading).

The idea that task components may be trained to an automatic level has been the focus of increasing interest over the past several years. One training procedure that has proven effective for producing automatic processing was developed by Schneider and Shiffrin (Schneider & Shiffrin, 1977; Shiffrin & Schneider, 1977) and is referred to as the constant mapping training procedure. These researchers have provided evidence that extensive practice (often over thousands of trails) using this procedure results in automatic processing of skill components, supposedly due to the reduction of attentional resources needed for performing these requisite components. It may be more parsimonious to say that such training may result in increased fluency, a term that denotes the combination of speed and accuracy, rather than reduced attention or automatic processing of skill components. Regardless of the nature of performance gains (e.g., fluency, automaticity, or reduced attentional resources), the idea that certain types of training may positively influence transfer, above and beyond traditional mastery level training, is both intriguing and may prove beneficial to many areas of training and education.

A conceptual framework for describing and testing aspects of the ART model is Gagne' and Briggs' (1979) learning hierarchy. A training outcome that is closely related to this model involves the transfer of lower-order (subordinate) skills to higher-order (superordinate) skills. This particular view of transfer is referred to as vertical transfer (Gagne', 1965).

The following sections of this paper will describe the dual task technique as well as briefly discuss issues concerning the use of the term "automaticity" in reference to results of such training procedures. Next, an overview of problems pertaining to terms used to communicate training outcomes related to transfer will be given. One particular aspect of transfer that we feel has potential for guiding research in the areas of training and instructional design, referred to as vertical transfer, will be described and subsequently used when describing the ART model. Following this, a detailed description of computer-based ART procedures that incorporate electronic symbols as training material will be presented. Finally, empirical issues related to this model and its application to educational settings will be addressed.

Implications of Automaticity Training for the ART Model

Historically, theorists have postulated at least two separate aspects of attention: mental activities that require a minimum of attention, referred to as automatic processes (Posner & Snyder, 1975; Schneider & Shiffrin, 1977; Shiffrin & Schneider, 1977) and mental activities that require increased amounts of attentional capacity. The latter type of mental processes have been referred to as conscious (Posner & Snyder, 1975), controlled (Schneider & Shiffrin, 1977), and effortful (Hasher & Zacks, 1979). We will use the term effortful for the sake of clarity. The idea of variable attentional capacity is based on a model of human information processing that assumes that the total amount of attentional capacity is limited (e.g., Kahneman, 1973). Kahneman's model also postulates that attentional limitations interact with processing demands at any point in the information-processing sequence (between encoding and responding) and that attentional requirements necessarily increase as processing nears the response end of the system (see also Posner & Keele, 1970). Thus, Kahneman's (1973) "variable capacity" model differs from other "bottleneck" models in that it doesn't hypothesize a specific processing stage where selective attention is thought to operate (see e.g., Broadbent, 1958; Keele, 1973; Norman, 1968).

In their article, Posner and Snyder (1975) listed several criteria for defining automatic processes including the following: automatic processes (a) may occur without intention, (b) do not necessarily give rise to awareness, (c) tend to interfere minimally with other cognitive processes. In a subsequent article, Hasher and Zacks (1979) expanded these criteria to include three additional characteristics based on a developmental framework. These characteristics were that once the components of a skill reached the automatic level, they (d) showed little improvement with age, (e) did not improve with continued practice, and (f) were relatively unaffected by differences in motivation, education, early experience, culture, and intelligence. In contrast, processes at the effortful end of the information processing continuum (a) interfere with the ability to perform other effortful tasks, (b) are most always available to consciousness, (c) are used voluntarily, and (d) tend to improve with practice (Posner & Snyder, 1975).

Researchers in cognitive psychology have extended this view of differential capacity requirements for mental activities and have argued that complex operations can, with extensive practice, occur with a minimum amount of attention allotted to them (Posner & Snyder, 1975; Schneider & Shiffrin, 1977; Shiffrin & Schneider, 1977). One technique found to facilitate automatic mental processing is referred to as the constant mapping technique (Schneider & Shiffrin, 1977; Shiffrin & Schneider, 1977). The constant mapping technique involves having subjects respond to a single stimuli or fixed set of stimulus items in the same way across numerous trials. Critical components of this technique will be described in the next section. Important to this discussion is a feature related to the nature of performance change as a function of constant mapping practice; namely, the reduction of attentional resources. This change was documented by Shiffrin and Schneider (1977). These researchers reported that after approximately 2100 trials, subjects were able to discriminate between two different sets of letters (same category condition) as fast as when they were required to discriminate between numbers and letters (different category condition). As a result of training, time to accurately respond in the same category condition was reduced from approximately 400 mseconds to 80 mseconds. This result was taken as evidence that processes can become automatic with sufficient practice using the constant mapping procedure and that the nature of skill components changes as it reaches the automatic level. That is, automatized skills do not require as much attention as evidenced by a dramatic decrease in reaction time performance. In addition, a dual task assessment procedure was used to verify reduction of attentional resources needed to perform the secondary task. That is, the secondary task (the skill of interest) was no longer affected by the number of processes being performed simultaneously.

Another study performed by Spelke, Hirst, and Neisser (1976) provided evidence that subjects could perform other dual tasks simultaneously and that subjects' performance levels change dramatically as a result of extensive practice. In this study, subjects were required to read silently and to simultaneously copy words dictated to them by the experimenter. Though very difficult at first, subjects were able to read while copying dictation as well as they had been able to read previous to the experiment. This result was taken as evidence that the skill of copying dictation had become automatic for the subjects, due to the fact that it did not interfere with their reading.

In the area of reading, recent theory and research has suggested that by automatizing critical prerequisite reading skills (e.g., letter recognition and word recognition) the reader can increase higher-level comprehension skills. For example, a theory of automatic information processing proposed by Laberge and Samuels (1974) has guided much of the research in this area. Their theory describes several stages involved in transforming written stimuli into meaning. A major facet of the theory is that there exists a limited-capacity attentional mechanism at each of the stages and that well-learned (i.e., automatized) stimuli may be processed and/or activated independent of attention at various levels of the system.

There is growing empirical evidence lending support to critical aspects of Laberge & Samuels (1974) theory. At the subword level, Staller and Sekuler (1975) report that letter naming speed of above average readers to be faster than for below average readers. At the word level, several articles have noted that oral reading speed of words is highly correlated with reading ability as measured by various standardized reading batteries. For example, Stanovich, Cunningham and Feeman (1984a) found that decoding speed of third and fifth graders, measured by subjects' vocalization latencies to words and psuedowords, was highly correlated to standardized reading test performance (see also Deno, Mirkin, & Chiang, 1982; Perfetti & Hogaboam, 1975; Stanovich et al., 1984b). In addition, at least two studies have presented results indicating that a causal relationship exists between automatic processing of individual words and performance on standardized reading tests (Lesgold & Resnick, 1982; Lomax, 1982). For example, Lesgold and Resnick (1982), using a causal modeling technique, presented evidence suggesting that a strong causal (nonreciprocal) path exists from word vocalization latency measures to reading comprehension.

It is apparent from the reading literature presented above that researchers in this area believe that automatic skill development of prerequisite reading skills can be measured by word vocalization latency measures. This observation has been noted in a recent review of this literature by Cohen (1987). However, to our knowledge, no empirical studies have investigated the possible relationship between word vocalization latency measures and attentional capacity. One way to study this is by comparing results of training using the secondary task technique with speeded measures. This possibility is explored in more detail in the next section.

Dual task paradigm methodology

As an assessment tool, the dual task relies on the following three assumptions: (1) both the primary and secondary tasks share a common pool of attentional resources, (2) primary task performance remains constant relative to when processing is independent of any competing tasks, and (3) primary task components don't become automatized with practice (Fisk et al., 1982). To satisfy the first assumption, it must be demonstrated that performance on one task necessarily decrease in the presence of the other, time-shared task. Since the competing (time-shared) task must consume a constant amount of attentional resources (assumption 2), it is usually labeled the primary task; that is, the task of primary importance for the subject. The fact that the subject performs the primary task at a level equal to when it is processed independent of any competing task allows one to infer that performance decrements related to the secondary task result from reduction of available attentional resources (when performing both tasks simultaneously).

The final assumption is particularly relevant to the ART model. Specifically, if both tasks being performed simultaneously are maintained over time or if independent trials in which they are performed are repeated, then one must consider the effects of this practice. That is, in order for the conditions set up by the first two assumptions to be maintained when dual tasks are practiced, evidence must be given indicating that the attentional resources related to the primary task have not attenuated. In their articles, Schneider and Shiffrin present evidence that use of a varied mapping practice procedure ensures that attentional resources won't decrease due to extended amounts of practice. Briefly, varied mapping practice involves having subjects vary their responses to a given stimulus item across trials.

In sum, the three assumptions just described allow one to describe decreases in secondary task performance as being a product of allocation of attentional resources to the primary task when using the dual task paradigm. By employing a dual task paradigm where the primary task responding conforms to a varied mapping practice procedure and secondary task responding conforms to a constant mapping practice procedure, a training procedure may be established that serves to reduce attentional resources related to the secondary task. Moreover, according to the current view of automaticity, if attentional resources used when performing a skill are reduced to a minimum (i.e., they don't interfere with other effortful processes), then they are thought to be automatic in nature. Within the context of the dual task paradigm, this would occur when performance of the secondary task becomes equal to pretraining (independent processing) levels. This event is presented graphically in Figure 1.

Insert Figure 1 about here

According to the scenario above, automaticity may be viewed as a continuous rather than a discrete phenomenon since the primary task may vary in complexity or difficulty. Thus, use of a simple primary task (e.g., reaction time to the presence or absence of a specified stimuli) would result in a level of automatic processing of secondary task components that is not equal to similar results using a more complex primary task (e.g., a decision making task involving instances of words and non-words). Our conception of dual task training incorporates varying primary task workload, which is designed to foster increased reduction of secondary task attentional resources. Workload is defined as the amount of attentional resources required to perform a specified task and can be assessed by measuring performance decrements of the secondary task (in terms of both accuracy and response latency).

Due to what we believe to be the continuous nature of automaticity and automatic processing, we prefer to call the result of training using the dual task paradigm attention reduction rather than automaticity. However, due to inherent problems involved in the sole use of secondary task performance measures to assess "automatic" skill processing as well as our idea of task "workload", we suggest that at least one other independent assessment tool be used.

Literature in the reading area offers several suggestions for assessing automatic skill processing in reading. For example, use of vocalization latencies has been suggested (e.g., Lesgold & Resnick, 1982). That is, present subjects with critical words, symbols, or concepts etc. and measure the latency for verbally identifying these stimuli. Once identified, these latencies can then be directly compared to the vocalization latencies of other, presumably automatically processed stimuli, such as digits or colors. The Stroop task (Stroop, 1935) has also been used for assessing automatic processing of words (see e.g., Stanovich, Cunningham, & West, 1981). However, use of this task in this way has been criticized (Cohen, 1987).

Issues Involving Communication of Training Outcomes Related to Transfer Effects

Two primary outcomes of training are maintenance and transfer (generalization). These terms refer to continued appropriate performance over time and across tasks and/or settings, respectively. The term transfer will be used throughout the remainder of this paper in reference to the combined concepts.

This discussion of transfer reviews several traditional distinctions used to describe transfer effects outlined by Royer (1979). It is our view that most traditional, descriptive labels used to communicate training outcomes related to transfer may confuse rather than enlighten. Of particular concern is the use of such terms as near and far when attempting to describe the extent or level of transfer effects. There is one aspect of transfer described by Royer (1979), referred to as vertical transfer by Gagne' (1965, 1985), that we feel has potential for guiding and evaluating future research within the area of education and instructional design. This aspect of transfer will be discussed in detail and will subsequently be used as a basis for describing an attention reduction model of training that may influence learning outcomes above and beyond traditional mastery training alone.

Traditional distinctions describing transfer effects

Several recent articles have focused on the theoretical aspects of transfer of training as well as skills thought to facilitate such transfer. For example, Royer (1979) described four conceptual distinctions that have traditionally been used to define transfer of training effects. Each distinction compares two seemingly dichotomous relations. One distinction that has been made involves specific and nonspecific transfer. Specific transfer describes a condition where the original and new (transferred) learning situations share common stimulus elements. For example, two different experimenters may teach the same skill (e.g., sharing) in the same (lab) setting. In contrast, nonspecific transfer situations do not share any common elements, besides some specified response set. A classic example of this type of transfer is "learning to learn" situations (Postman, 1969).

A second distinction described by Royer is that of literal verses figural transfer. In literal transfer, and intact skill is directly used in the new learning situation. For example, you can directly apply knowledge of synaptic transmission to understand symptoms related to Parkinsons's disease. Figural transfer is described as a tool for learning in novel situations, and involves using some instance or unit of world knowledge to aid understanding. One common example is learning by analogy. For example, describing human information processing in terms of a computer.

A third and often-cited distinction used to describe transfer is that of near and far transfer. Near transfer, as originally defined by Mayer (1975), refers to a situation where both the original and new learning contexts are highly similar. An example of near transfer is learning to add two-digit numbers and assessing this skill with three-digit numbers. Far transfer is used to describe new learning situations that are "somewhat" different from the original learning context. Thus, being taught the skill of making change by an experimenter in a lab setting and subsequently using this skill when buying groceries in a store would constitute far transfer of the "making change" skill.

A fourth distinction compares vertical and lateral aspects of transfer and is based on Gagne's (1965) analysis of learning outcomes. The former he defined as use of a subordinate skill or skills when performing a superordinate skill. For example, the use of multiplication and subtraction skills when learning to divide. Lateral transfer refers to applying skills in one confined context (e.g., classroom) to some other, novel situations (e.g., real life). Thus, learning to calculate the area of a rectangle in school and using this knowledge to determine the size of a rug at home would constitute lateral transfer of this math skill. It should be noted that the notion of vertical transfer fits well with the objective-based training model (e.g., Gagne' & Briggs, 1979). Since vertical transfer describes a condition in which a subordinate skill is used when performing another, superordinate skill, the notion that two or more skills may be related in a hierarchical fashion becomes paramount to this view of transfer. Implications of vertical transfer for an objective-based training model will be outlined in the next section.

It is evident that there is much overlap between these four distinctions. In fact, differences that may exist between some of the distinctions may only be due to the examples used to describe them. For example, near and specific transfer appear only to differ in that specific transfer is related to the context of the learning environment (e.g., use of two different experimenters), and near transfer is described in terms of the stimulus features (e.g., use of three- instead of two-digit number). It should be noted that Royer (1979) glosses over this distinction by describing his definition of near transfer as referring to "... one school-learned-event to another school-learned-event (p. 56)." This illustrates the need for researchers in the area to agree on some guidelines for evaluating training outcomes related to transfer of training effects. In this regard, Jacobs (1986) found evidence of inconsistent use of the terms near and far transfer by researchers when describing results of reading training studies (see e.g., Bauman, 1984; Short & Ryan, 1984, p. 233). In his discussion, Jacobs (1986) cautioned researchers within the training area to avoid such descriptive labels in this context unless their value to clearly communicate results has been established. This caution appears timely, since some researchers (Brown & Campione, 1984, p. 164) have suggested using yet another descriptive label (i.e., very far transfer) despite the apparent confusion surrounding the use of near and far. A similar posture has been adopted by some researchers in the area of clinical diagnosis due to the (continuing) controversy regarding the adoption and use of certain diagnostic labels (see e.g., Achenbach, 1980).

Implications of vertical transfer for an objective-based model of instruction

The skills necessary to perform an objective task and the relationships among these skills are identified by means of an instructional analysis. One widely used method of analysis, hierarchical analysis, is based on Robert Gagne's taxonomy, (Gagne', 1965, 1985; Gagne' & Briggs, 1979). Hierarchical analysis is used most frequently when the learning outcome is an intellectual skill. Using hierarchical analysis, intellectual skills identified as being part of a job task are broken down into those subordinate skills that are required by a given target population to achieve a terminal (or superordinate) objective. A hierarchical relation exists between skills if appropriate performance of one (subordinate) skill must necessarily predate the performance of another (superordinate) skill.

The relationship among skills is determined by asking the question: Is this skill needed in order to perform a higher-order skill? Another perspective is to take the higher-order skill and ask: What other skill, if not taught, would make performance of this superordinate skill impossible? Skills identified using these two procedures are thought to be hierarchical in nature. For example, to use spreadsheet functions one must be proficient with multiplication and division operations. To multiply and divide for this purpose one must be able to perform addition with carrying and subtraction with borrowing. Prerequisite to these skills are the ability to add without carrying and subtract without borrowing. The hierarchical nature of these skills is clear. Performance of the superordinate skill depends on adequate performance of the other, subordinate skill.

When used to assist trainees in learning complex job tasks, instructional theory dictates that an instructional analysis focusing on the types of required learning be performed. Job tasks associated with electricity and electronics tasks have hundreds of potential intellectual skills associated with them. Millions of dollars are spent each year in training electricians and electronics technicians in the prerequisite skills necessary for the performance of higher-level technical tasks. A prerequisite objective that is, or should be, included in a learning analysis pertaining to electricity and electronics skill areas involves schematic symbols (cf., Cleaver, Meeusen, & Wells, 1966, p.V). Using Gagne' and Briggs' standard capability verb for a concrete concept, the trainee should be able to identify common schematic symbols.

Although the prerequisite objective of identifying schematic symbols is unquestionably an essential part of upper-level skills such as troubleshooting a complex electrical circuit, instruction rarely focuses on training these critical skills. In contrast, large amounts of time and resources are expended to help trainees identify various electrical circuits, which are configurations of schematic symbols.

Training aimed at facilitating identification of schematic symbols may focus on variable attributes of the to-be-learned concept, critical attributes needed for concept identification, or both sets of attributes. Particularly with coordinate concepts, learning the variable attributes of related concepts is important. Even so, some instructional research (Tennyson, 1978; Tennyson, Youngers, & Suebsonthi, 1983) suggests that trainees should first become exposed to a "best example" of each schematic symbol component. As an instructional design variable, a best example "represents an average, central, or prototypical form of a concept" (Tennyson & Cocchiarella, 1986, p.61). In the case of schematic symbols, such as diodes that are varied in shape, a best example should encode in memory a clear prototype that represents the more common dimensions of the concept class.

Methodology for Designing and Evaluating a Computer-Based ART Model

Primary task parameters

At the present time, a relatively simple discrimination task will be used as the primary task. This task involves having subjects listen to two sequentially presented tones (produced by the computer) and press one key if the second tone is higher in pitch than the first and another key if it is lower in pitch. The response mode of this task will be reversed on every other trial by having subjects discriminate between the tones according to whether or not the second tone is lower then the first tone. This is done in accordance with the varied mapping practice procedure described previously. Stimulus items for this task include several tones that can be easily discriminated from one another. Also, the tones are randomly produced so that on the average 50% are higher and 50% lower (for each set of 30 tones) than the one before it. At no time are two consecutive tones the same pitch. The presentation rate of the sets of tones will be adjustable from approximately one to five seconds. The latency between pairs of tones will be short (less than one second). We will use pilot data to identify the optimal number and the presentation rate of the tones. The computer will record and store accuracy and latency data for individual subjects for each trial (see below). In addition, task parameters involving rate of presentation and latency between tones will be adjustable in order to vary the difficulty, and thus workload, of the primary task. In this way, we can increase or decrease concomitant attentional resources needed to perform the secondary task.

Secondary task parameters

The secondary task consists of 20 common electrical schematic symbols presented one at a time. These symbols are presented in Figure 2. A single trial will consist of individual responses to all 20 symbols. The computer randomly orders the symbols prior to each trial. For each symbol, subjects will be presented a single schematic symbol name. On the average, 90% of the name-symbol pairings will be correct. This rate was recommended by Schneider and Shiffrin in their 1977 articles. The subjects' task will be to identify whether or not the schematic name correctly matches the schematic symbol. A key-press response will be used for recording their answer. In addition, a variation of training for this task will involve rotation of individual symbols. Also, the keys used for both primary and secondary tasks will be arranged so that one hand responds to one task while the other hand responds to the other task. The program will be made flexible so that the subjects dominant hand will always respond to the secondary task and vice versa. This will allow us to use both primary and secondary tasks simultaneously and thereby utilize both procedures within a dual task training paradigm.

Insert Figure 2 about here

There are at least three criteria that may be employed for judging if processing demands related to the secondary task have been reduced as a result of training. First, the dual task procedure may be used to test attentional demands needed when performing the secondary task. Assessment in this context involves comparing secondary task performance (i.e., accuracy and latency data) in the presence of a competing task to baseline performance levels. Training can be considered complete if performance levels in each of these situations are approximately equal. Second, vocalization latency data can be collected involving digits and/or colors for individual subjects. These data can then be compared to vocalization latencies of schematic symbols. Thus, each subject will act as his or her own control. A third procedure can also be used for assessing training also involves vocalization latencies. That is, vocalization latencies of schematic symbols of subject matter experts (e.g., electrical engineers) can be collected and used as a standard for comparing latencies of subjects.

Transfer Task

The transfer task is an integral part of our experimental design, since a major goal of the ART model is to facilitate vertical transfer effects above those found for mastery training alone. The transfer task we have chosen involves having subjects identify a novel simple circuit within larger schematic configurations. An example of a simple circuit is shown in Figure 3.

Insert Figure 3 about here

The configurations within which these circuits will be embedded will vary in their level of complexity. Examples of three levels of configuration complexity is shown in Figure 4. The design of the configurations is consistent with aspects of a Rational Set Generator (RSG) model developed by Driscoll and Tessmer (1985a, 1985b; see also Dempsey, 1986 describing adaptation of this model for use on the computer). For example, levels of complexity will be determined by varying such factors as (a) the total number of symbols in the configuration, (b) whether or not the symbols in the simple circuit are presented in the same sequence as when it is originally presented, (c) whether or not the simple circuit is rotated when imbedded in the configuration (relative to its original visual orientation), and (d) combinations of a, b, and c.

Insert Figure 4 about here

The basic procedure will involve presenting subjects with several simple circuits. After a brief (60 second) familiarization period, subjects will be asked to identify these circuits within a series of schematic configurations. Several examples will be given first, to familiarize them with this task. Configurations can then be presented on a computer and the subjects task is to touch the area of the configuration that incorporates a particular circuit. The subject will then be given a chance to identify the circuit by typing in some identifying code for that particular circuit. The computer will collect data on accuracy of responses (i.e., number of correct "hits" and errors of commission and omission) as well as time to correctly locate the circuits. Presentation of the configurations will be random and based on computer adaptation of the RSG model (Dempsey, 1986). In addition, presentation of the original simple circuits can be used as probes during the presentation sequence in order to directly test for memory of the simple circuits.

Traditional methodology for assessing ART model

Based on previous research (Schneider & Shiffrin, 1977; Shiffrin & Schneider, 1977), one way to reduce attentional resources related to a skill is to use a constant mapping practice procedure. Using this procedure, one can reduce attentional resources related to the secondary task (described above) and then test the hypothesis that this type training facilitates vertical transfer. The superordinate skill in this case is recognition of electrical circuits (described below). The procedure for testing this hypothesis is as follows:

(1) Provide initial (mastery) training to all subjects regarding identification of the 20 electrical symbols.

(2) Collect pretraining (baseline) data on both the primary and secondary tasks in terms of accuracy and response latencies. This can be done using the computer.

(3) Randomly assign half of the subjects to an ART condition using the constant mapping procedure. Assess reduction of attentional resources using a dual task procedure. Provide continued practice to the remaining subjects in order to control for general "practice" effects.

(4) Assess learning outcomes related to vertical transfer using all subjects.

Alternative methodology for assessing ART model

A second paradigm may also be used for examining aspects of vertical transfer using the dual task procedure as a training device. The procedure employing this alternative methodology is as follows:

(1) Provide (mastery) training to all subjects regarding identification of 20 electrical schematic symbols. Collect baseline vocalization latency data on naming digits and/or colors as well as for identification of 20 schematic symbols.

(2) Randomly assign half of the subjects to ART condition that utilizes dual task training as means to reduce attentional resources related to secondary task. For these subjects, training proceeds as follows: (a) assess pretraining (baseline) performance for both primary and secondary task, (b) primary task presented for short period to insure responding is similar to baseline levels, (c) secondary task added to primary task with instructions to subject to focus on performing primary task at original (baseline) levels, and (d) continue combined training until secondary task reaches baseline levels, making sure primary task performance remains constant. For other subjects, continue mastery training to control for potential practice effects. One variation of this design is to gradually increase primary task difficulty, thereby assessing the effects of variable levels of reduced attention with regard to vocalization latencies and vertical transfer for the secondary task.

(3) Assess effects of ART training by collecting vocalization latencies of 20 schematic symbols for all subjects. This will provide a direct comparison between ART model using dual task procedures and a discrete measure of automatic processing based on vocalization latency measures.

(4) Assess vertical transfer effects using all subjects.

Issues impeding application of the ART model for use in educational settings

There are several issues that must be empirically addressed before the ART model would be feasible for educational applications. These issues include the following:

(a) Incrementing task workload. That is, what is the best way to increase primary task workload? For some individuals, smaller increments would be optimal, but for others, larger increments may facilitate training. The deciding factor here may be the learner's response to failure. For example, if the learner becomes motivated in the face of wrong answer feedback, thereby increasing his or her performance on subsequent trials, then larger task workload increments may be used. If the learner tends to give up easily when their performance level is low, then smaller increments may be needed.

(b) Optimal primary task workload for producing durable attention reduction processing. In general, the ART model views attentional resources as being continuous in nature. Given that this training technique facilitates training and transfer in some meaningful way, there is a need to determine optimal levels of reduced attention for specific tasks and/or individuals.

(c) Use of multiple primary tasks. Providing a single competing task and varying specific task parameters (e.g., rate of tones or discriminability between tones) is only one way to increase task workload. Another possibility is to add more competing tasks, so that the learner must respond to each. This approach may be more realistic in the sense that in real-life situations, our attention is divided into several tasks simultaneously. For example, when reading, attention is given to individual word meanings, to literal comprehension of individual sentences, as well as to whether or not perceived meaning matches our knowledge and experience. However, in practice, setting up and monitoring several simultaneous tasks may not be feasible, if for not other reason, the mode of response of one task may interfere with encoding or responding to other tasks.

(d) Use of speeded training techniques for accomplishing attention reduction training. The reading literature has demonstrated the importance of speeded measures (e.g., recognition latency data) with respect to certain basic skills such as individual word recognition. Since researchers in this area have suggested that speed may be a critical component of automatic processing, there is a need to explore the relation between ART and training aimed at decreasing speed (e.g., repetitive reading). Results from such studies could be used to bolster the assumption that increases in speed may be attributed, in part, to a reduction in attentional resources. Conversely, it may be the case that automaticity is composed of two separable factors, reduced attention and increased speed. In either case, the results would be useful for designing and evaluating future models of training that view skill mastery as only one facet of efficient learning.

References

Achenbach, T. M. (1980). DSM-III in light of empirical research on the classification of child psychopathology. *Journal of the American Acadamy of Child Psychiatry*, *19*, 395-412.

Bauman, J. F. (1984). The effectiveness of a direct instruction paradigm for teaching main idea comprehension. *Reading Research Quarterly*, *20*, 93-115.

Britton, B. K., Piha, A., Davis, J., & Wehausen, E. (1978). Reading and cognitive capacity usage: Adjunct question effects. *Memory and Cognition*, *6*, 266-273.

Britton, B. K., & Tesser, A. (1982). Effects of prior knowledge in the use of cognitive capacity in three complex tasks. *Journal of Verbal Learning and Verbal Behavior*, *21*, 421-436.

Broadbent, D. E. (1958). *Perception and communication*. London: Pergamon Press.

Brown, A. L., & Campione, J. C. (1979). Inducing flexible thinking: A problem of access. In M. Friedman, J. P. Das & N. O'Connor (Eds.), *Intelligence and learning* (pp. 515-529). New York, NY: Plenum Press.

Brown, A. L., & Campione, J. C. (1984). Three faces of transfer: Implications for early competence, individual differences, and instruction. In M. Lamb, A. Brown & B. Rogoff (Eds.), *Advances in developmental psychology* (Vol. 3, pp. 143-192). Hillsdale, NJ: Erlbaum.

Cleaver, R. J., Meeusen, E. J., & Wells, R. A., Jr. (1966). *Fundamentals of Electricity, Vol. 1 - Baine Principles*. Addison-Wesley Publ. Co., Inc.: Reading, Mass.

Cohen, A. L. (1987). The functional relevance of reading automaticity. Unpublished manuscript, Florida State University, Tallahassee.

Dempsey, J. (1986). Using the rational set generator with computer-based instruction for creating concept examples: A template for instructors. *Educational Technology*, *26*, (4), 43-46.

Deno, S., Mirkin, P., & Chiang, B. (1982). Identifying valid measures of reading. *Exceptional Children*, *49*, 36-47.

Driscoll, M. P., & Tessmer, M. (1985a). The rational set generator: A method for creating concept examples for teaching and testing. *Educational Technology*, *25*(2), 29-31.

Driscoll, M. P., & Tessmer, M. (1985b). Applications of the concept tree and rational set generator for coordinate concept learning. Manuscript submitted for publication.

Driscoll, M. P., & Tessmer, M. (1986). Determining the locus of effect of the concept tree for coordinate concept learning. Manuscript submitted for publication.

Eysenck, M., & Eysenck, C. (1979). Processing depth, elaboration of encoding, memory stores, and expanded processing capacity. *Journal of Experimental Psychology: Human Learning and Memory*, *5*, 472-484.

Fisk, A. D., Derrick, W. L., & Schneider, W. (1982). The use of dual task paradigms in memory research: A methodological assessment and an evaluation of effort as a measure of levels of processing (Technical report 8105). Champaign, Ill: University of Illinois, Human Attention Research Laboratory, March.

Gagne', R. M. (1985). *The conditions of learning* (Fourth edition). New York, NY: Holt, Rinehart and Winston.

Gagne', R. M. (1965). *The conditions of learning* (First edition). New York, NY: Holt, Rinehart and Winston.

Gagne', R. M., & Briggs, L. J. (1979). *Principles of instructional design*. New York, NY: Holt, Rinehart, & Winston.

Hasher, L., & Zacks, R. T. (1979). Automatic and effortful processes in memory. *Journal of Experimental Psychology: General*, *108*, 356-388.

Jacobs, J. W. (1986). Developing models of strategic reading: Theoretical and empirical issues involved in training executive processes. Unpublished manuscript, Florida State University, Tallahassee.

Kahneman, D. (1973). *Attention and effort*. Englewood Cliffs, N.J.: Prentice-Hall.

Keele, S. (1973). *Attention and human performance*. Pacific Palisades, Calif.: Goodyear.

LaBerge, D., & Samuels, S. J. (1974). Toward a theory of automatic information processing in reading. *Cognitive Psychology*, *6*, 293-323.

Lesgold, A. M., & Resnick, L. B. (1982). How reading difficulties develop: Perspectives from a longitudinal study. In J. P. Das, R. F. Mulcahey & A. E. Walls (Eds.). *Theory and Research in Learning Disabilities*. New York: Plenum Press.

Lomax, R. G. (1982). Causal modeling of reading acquisition. *Journal of Reading Behavior*, *14*, 341-345.

Mayer, R. E. (1975). Information processing variables in learning to solve problems. *Review of Educational Research*, *45*, 525-541.

Mechner, F. (1967). Behavioral analysis and instructional sequencing. In P. Lange (Ed.), Programmed instruction: 66th yearbook for the national society for the study of education, Part II. Chicago: Univ. of Chicago Press.

Norman, D. A. (1968). Toward a theory of memory and attention. Psychological Review, 75, 522-536.

Perfetti, C. A., & Hogaboam, T. (1975). Relationship between single word decoding and reading comprehension skill. Journal of Educational Psychology, 67, 461-469.

Posner, M. I., & Keele, S. W. (1970). Retention of abstract ideas. Journal of Experimental Psychology, 83, 304-308.

Posner, M. I., & Snyder, C. R. R. (1975). Attention and cognitive control. In R. L. Solso (Ed.), Information processing and cognition: The Loyola Symposium. Hillsdale, N.J.: Erlbaum.

Postman, L. (1968). Experimental analysis of learning to learn. In G. H. Bower & J. T. Spence (Eds.) The psychology of learning and motivation (Vol. 3), New York, NY: Academic Press.

Royer, J. M. (1979). Theories of transfer. Educational Psychologist, 14, 53-69.

Schneider, W., & Shiffrin, R. M. (1977). Controlled and automatic human information processing: I. Detection, search, and attention. Psychological Review, 84, 1-66.

Shiffrin, R. M., & Schneider, W. (1977). Controlled and automatic human information processing: II. Perceptual learning, automatic attending, and a general theory. Psychological Review, 84, 127-190.

Short, E. J., & Ryan, E. B. (1984). Metacognitive differences between skilled and less skilled readers: Remediating deficits through story grammar and attribution training. Journal of Educational Psychology, 76, 225-235.

Spelke, E., Hirst, W., & Neisser, U. (1976). Skills of divided attention. Cognition, 4, 215-230.

Staller, J., & Sekuler, R. (1975). Children read normal and reversed letters: A simple test of reading skill. Quarterly Journal of Experimental Psychology, 27, 539-550.

Stanovich, K. E., Cunningham, A. E., & Feeman, D. J. (1984a). Intelligence, cognitive skills, and early reading progress. Reading Research Quarterly, 19, 278-303.

Stanovich, K. E., Cunningham, A. E., & Feeman, D. J. (1984b). Relation between early reading acquisition and word decoding with and without context: A longitudinal study of first-grade children. Journal of Educational Psychology, 76, 668-677.

Stanovich, K. E., Cunningham, A. E., & West, R. F. (1981). A longitudinal study of the development of automatic recognition skills in first graders. Journal of Reading Behavior, 13, 57-74.

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. Journal of Experimental Psychology, 18, 643-661.

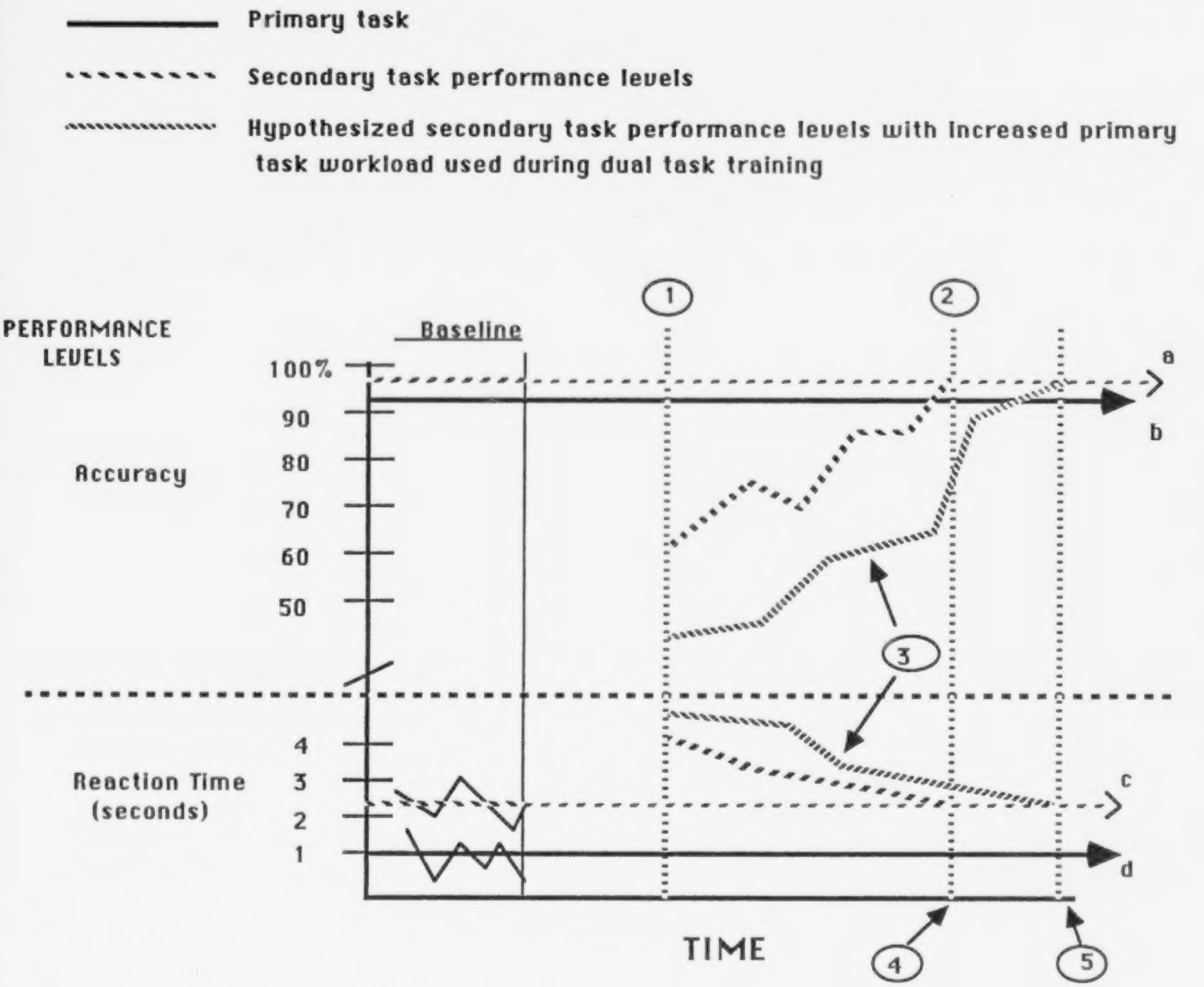
Tennyson, R. D., & Cocchiarella, M. J. (1986). An empirically based instructional design theory for teaching concepts. Review of Educational Research, 56(1), 40-71.

Tennyson, R. D. (1978). Pictorial support and specific instructions as design variables for children's concept and rule learning. Educational Communication and Technology Journal, 26, 291-299.

Tennyson, R. D., Youngers, J., & Suebsonthi, P. (1983). Concept learning by children using instructional presentation forms for prototype formation and classification-skill development. Journal of Educational Psychology, Vol. 75, No. 2, 280-291.

Tyler, S., Hertal, P., McCalum, M., & Ellis, H. (1979). Cognitive effort and memory. Journal of Experimental Psychology: Human Learning and Memory, 5, 607-617.

Wagner, R. K., & Sternberg, R. J. (in press). Executive control in reading comprehension. To appear in B. K. Britton (Ed.), Executive control processes in reading. Hillsdale, NJ: Erlbaum.



① Dual task training begins now

a thru d - Extended baselines for accuracy and RT performance levels

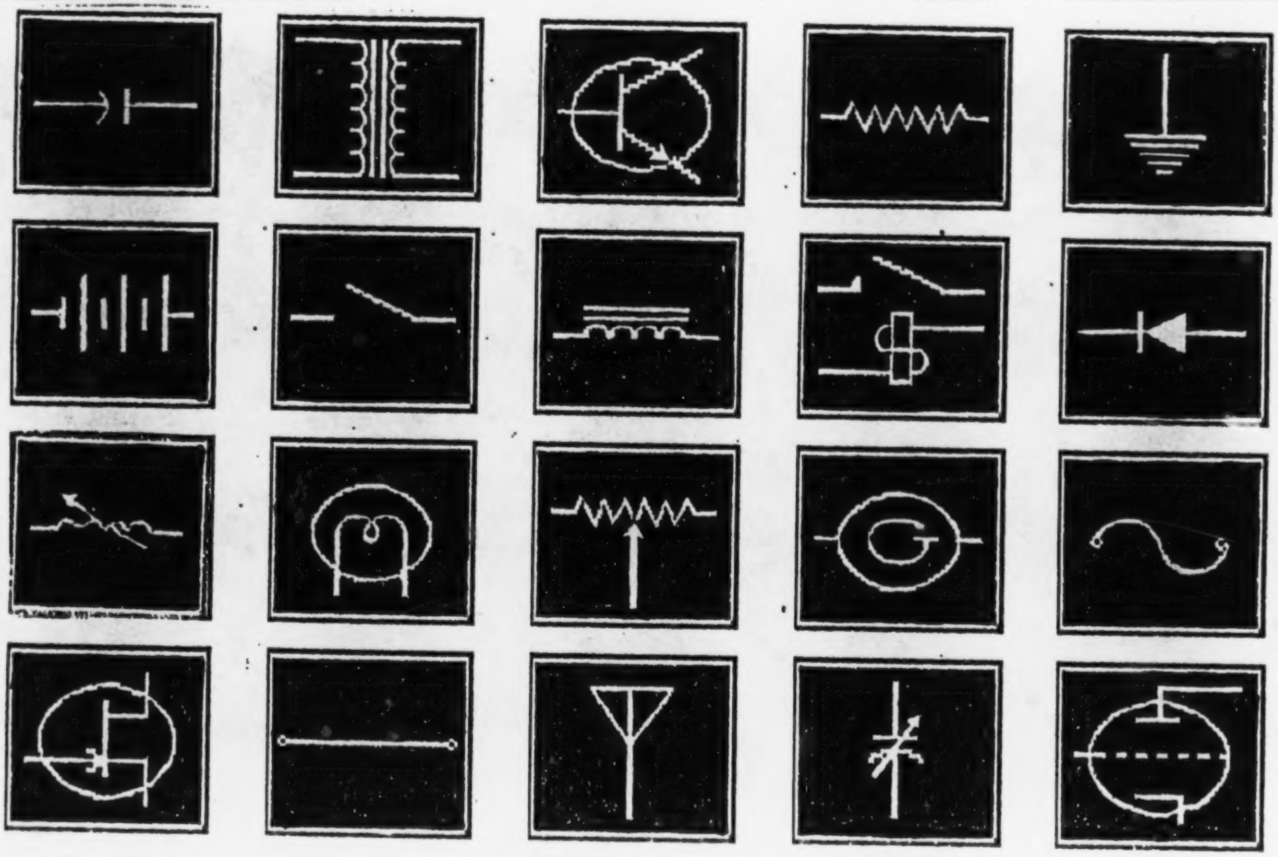
② Attention reduced via dual task training - automaticity thought to occur at this point in time

③ Hypothesized secondary task performance pattern when using primary task having greater cognitive workload

④ & ⑤ Assess voice latencies at points 4 & 5 as independent measure of amount of reduction of attentional resources

Figure 1

Primary and Secondary Task Performance Patterns
Resulting from Attention Reduction Training Using Dual Task Technique



Row #1 (top): capacitor, transformer, transistor, resistor, ground

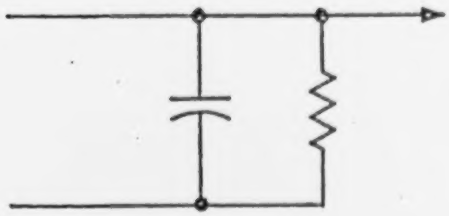
Row #2: battery, switch, inductor, relay, diode

Row #3: variable inductor, lamp, potentiometer, generator, fuse

Row #4: FET, conductor, antenna, variable capacitor, electron tube

Figure 2

Common Electrical Schematics Used as
Secondary Task Stimuli for ART Study



single capacitor with bleeder

Figure 3

Example of Simple Circuit Used in Transfer Task

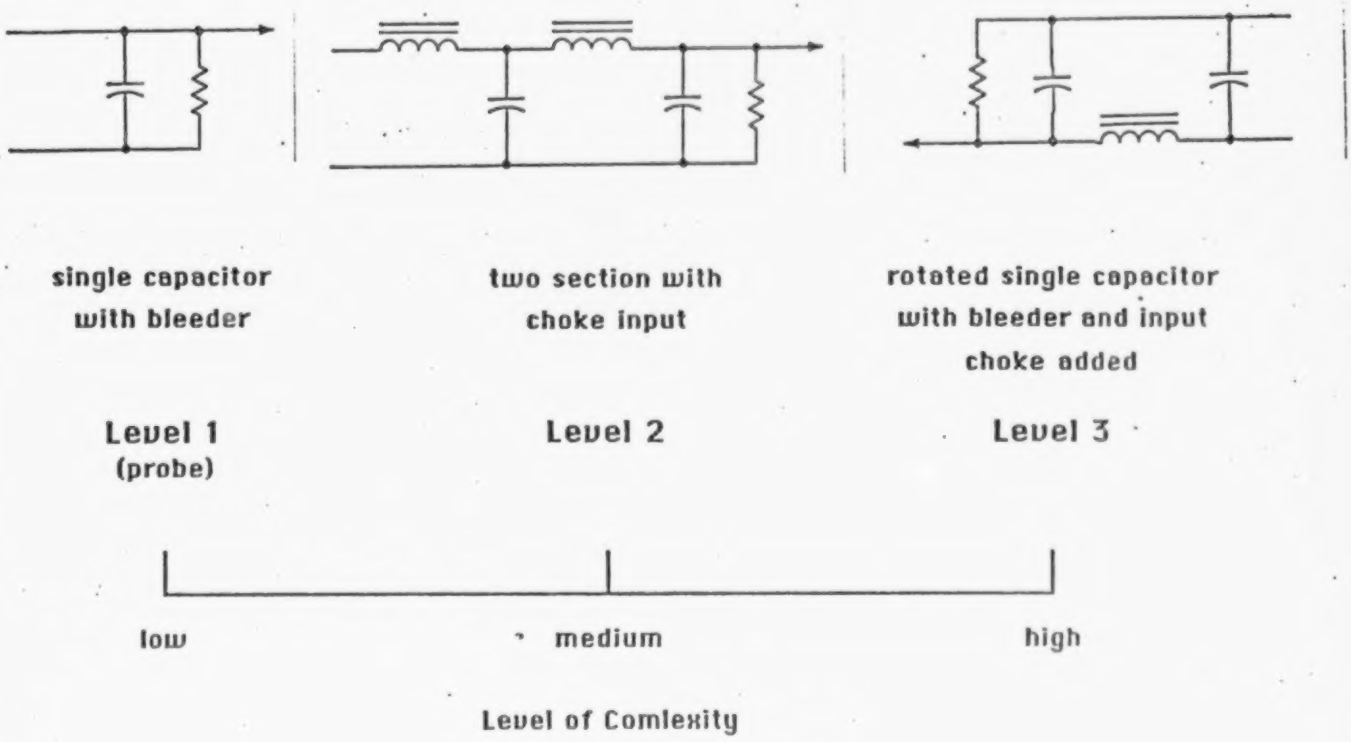

single capacitor with bleeder
Level 1
(probe)
two section with choke input
Level 2
rotated single capacitor with bleeder and input choke added
Level 3
low
medium
high
Level of Comlexity

Figure 4

Example Schematic Configurations at Three Levels of Complexity for Use in Transfer Task

Field-Dependence/Independence and the Mathemagenic Effects of Observable Visual Imagery Rehearsal for Learning from Computer-Presented Text

John H. Joseph
The Pennsylvania State University
Capital College
Middletown, PA 17057

Paper presented at the Annual Convention
Association for Educational Communications and Technology
Research and Theory Division
Atlanta, February 27, 1987

Field-Dependence/Independence and the Mathemagenic Effects of Observable Visual Imagery Rehearsal for Learning from Computer-Present Text

This study examines the effectiveness of observable visual imagery strategy for encoding of verbal information. Of particular interest is the relative effectiveness of the strategy for field-independent and field-dependent learners.

Much instruction is presented verbally, particularly through text. The increased use of videotext in conjunction with computer-based instruction promises continued and increased reliance on this most efficient medium of instructional communication.

Rothkopf (1) developed the concept of mathemagenic behaviors to describe attending phenomena "that are relevant to the translation of the written stimuli into internal representation." Adjunct questions are frequently cited as an example of a mathemagenic technique to enhance learning from text. Various studies have shown that these mathemagenic techniques improve learning.

A number of authors have cited the important and complex role of visual imagery in learning (Fleming and Hutton (2), Hortin (3), Levin (4), Pavio (5)). Hortin (2) studied the use of imagery to solve verbal problems and found that external representation of thoughts led to increased participation in learning activities. Slee (6) concluded that individual differences interact with the effectiveness of visual imagery strategies, particularly for encoding of visual material. However, she emphasized that visual imagery strategies can play a positive role "in the encoding of verbal material for those individuals capable of generating relational images of words' referents."

The issue of provided versus generated pictures also seems bound to individual differences. Levin and Pressley (7) report conflicting evidence to support both approaches and conclude "that at least for elementary and junior high school students, imposed pictures are certainly as good as induced images, and in some cases better." They point out that there is not yet evidence to generalize about adults.

The dimension of relative field-dependence has been extensively studied in relation to instructional strategies. This measure of perceptual style is found to correlate generally with intellectual functioning important to learning and instructional strategy. Its relevance to this study is based, at least in part, on the cognitive functioning associated with the generation of visual representations of verbal information. As Witkin, et.al. (8) point out in their manual for the Embedded Figures Test,

> ...the ability to analyze experience and the ability to structure experience are both aspects of increasing articulation. Just as the concept of increasing articulation has been applied to experience of an immediately present stimulus configuration (perception) so may it be applied to experience of symbolic material (thinking).

The purpose of this study is to investigate the effectiveness of observable visual imagery rehearsal as a mathemagenic technique for learning from computer presented text instruction. Learning was measured through criterion tests designed to measure achievement of different specific objectives. The effects were measured for subjects identified as either field-dependent or field-independent.

Procedure

Subjects were 54 college undergraduate and graduate students renging in age from 20 to 54 years. Some subjects were paid $5.00 to participate on a voluntary basis and some participated without pay as part of a course requirement. All subjects were randomly assigned to treatments.

The subjects were divided into two groups on the basis of scores on the Group Embedded Figures Test. For the purposes of this study, "field dependent" scores ranged from 0-10 while "field-independent" scores ranged from 11-18.

The instructional unit and criterion tests were those developed and used by Dwyer (9). The 2,000 word instructional unit deals with the construction and operation of the heart and is accompanied by 37 visuals which illustrate concepts and relationships for which visualization is likely to be beneficial.

The criterion tests were a drawing test with 18 items and identification, terminology and comprehension tests with 20 items each. Together these four tests constituted a total criterion test. Reliabilities (KR-20) of the individual tests equal or exceed .77. The reliability of the total test is .92. Subjects were administered a pretest to determine their prior knowledge of human physiology.

The three experimental conditions were (1) computer presented text without visuals or rehearsal strategies (control), (2) text accompanied by line drawings presented on a handout and (3) text with visual imaging tasks corresponding to the line drawings in treatment two. Subjects in treatment three were instructed to sketch (roughly and for their own benefit) visual representations of the information presented in each frame. All subjects received the criterion tests immediately following the instruction.

The instruction and tests were administered with IBM Personal Computers using the McGraw-Hill Interactive Course Authoring System.

The analysis involved a two-factor design with repeated measures designated RS9 in (A2 @ B3) @ J4. Random subjects were nested in cells formed by the two factors:

> Factor A: Two levels of the cognitive style variable, 1) High, field independent and 2) Low, field dependent;
>
> Factor B: Three levels of the instructional variable, 1) no illustrations or rehearsal strategy (control), 2) line drawings and 3) observable visual imagery rehearsal.

The cells were crossed by Factor J, four levels of the criterion measure; 1) drawing test, 2) identification test, 3) terminology test and 4) comprehension test.

A separate analysis was conducted for the total test composed of the four subscores.

The library program ANOVR was used for the analysis of variance procedures.

Results and Discussion

The analysis of variance procedures for the four individual tests produced significant (.05) F values for only the field-dependence factor and the repeated measure main effects. The conventional ANOVA summary table is presented in Table 1, attached.

The analysis of variance procedure for the total test scores produced a significant F value for only the field-dependence factor main effect. This ANOVA summary table is presented in Table 2, attached.

Accordingly, no significant differences of interest were found in the analysis of variance. Nevertheless, examination of the means reveals some interesting, if not significant, trends. The means are presented in Figure 3, attached.

As indicated by the total test score means, field-independent subjects benefitted most from presented line drawings and, moreover, scored markedly lower when required to engage in the observable visual imagery strategy.

In contrast, field-dependent subjects scored higher when required to engage in the observable visual imagery rehearsal. This improvement was evidenced in each separate test, except for a slight superiority of the control group in the case of the comprehension test.

Obviously, the results cannot support conclusions about the research question; however the consistent patterns of scores suggests that further investigation with greater control might detect differential benefits of the strategy for learners who differ in field-dependence.

A number of factors could have contributed to the variability of scores and reduced power to detect any differences in the treatments. Practical considerations precluded the use of subjects whose ages and general ability were more homogeneous. Similarly, variance may have resulted from the use of both paid volunteers and subjects required to participate as part of a course. Of course, larger cell sizes would increase power as well; the N of nine in this study was based on a power calculation using a variance derived from an earlier study with a less diverse sample.

Notwithstanding the possibility of undetected differences related to field dependence/independence, the results of this study of adult learners correspond to findings of Levin and Pressley (7) for younger learners, that provided pictures are equally effective as generated pictures.

Table 1. Analysis of Variance, RS9 in (A2 @ B3) @ J4

Source	df	Sums of Squares	Mean Squares	F ratio
Between Subjects				
Field-Dependence	1	411.13	411.13	7.766*
Treatments	2	1.36	0.68	0.013
F-D X Treatments	2	86.40	43.20	0.816
Error	48	2540.94	52.94	
Within Subjects				
Criterion Tests	3	386.76	128.92	16.088*
F-D X Tests	3	24.91	8.30	1.036
Treatments X Tests	6	83.49	13.92	1.736
F-D X Tests X Treatments	6	18.90	3.15	0.393
Error	144	1153.94	8.01	

*p < .01

Table 2. Analysis of Variance, RS9 in (A2 @ B3) - Total Score

Source	df	Sums of Squares	Mean Squares	F ratio
Between Subjects				
Field-Dependence	1	1644.52	1644.52	7.76*
Treatments	2	5.44	2.72	0.01
F-D X Treatments	2	345.59	172.80	0.82
Error	48	10163.78	211.75	

*p < .01

	J1 Drawing	J2 Ident.	J3 Termin.	J4 Comp.	Total Score
B1 Control	9.11	14.22	13.44	12.89	49.67
B2 Line Drawing	11.22	16.44	12.89	11.11	51.67
B3 Imagery	10.00	12.78	11.44	10.66	44.89

A1, Field-Independent

	J1 Drawing	J2 Ident.	J3 Termin.	J4 Comp.	Total Score
B1 Control	7.44	9.66	9.66	10.33	37.11
B2 Line Drawing	6.67	11.22	8.67	8.77	35.33
B3 Imagery	8.89	11.56	10.22	10.00	40.67

A2, Field-Dependent

Figure 1. Cell Means (N=9)

References

1. Rothkopf, E.Z. (1980) "Analysing eye movements to infer processing styles during learning from text." In Hartley, J.I. (Ed.) The Psychology of Written Communication. New York: Nichols Publishing Company.

2. Fleming, M.L. and Hutton, D.W. (1983) Mental Imagery and Learning. Englewood Cliffs, NJ: Educational Technology Publications.

3. Hortin, J.A. (1985) "Using Imagery Training to Solve Puzzles." Paper presented at 1985 A.E.C.T. Convention.

4. Levin, J.R. (1972) "When is a picture worth a thousand words?" In Issues in Imagery and Learning: Four Papers. Madison, WI: Wisconsin Research and Development Center for Cognitive Learning.

5. Pavio, A. (1971) Imagery and Verbal Processes. N.Y.: Holt, Rinehart and Winston.

6. Slee, J.A. (1983) "The use of visual imagery in visual memory tasks: A cautionary note." In Fleming and Hutton (1983), above.

7. Levin, J.R. and Pressley, M. (1983) "Understanding mnemonic imagery effects: A dozen "obvious" outcomes." In Fleming and Hutton (1983), above.

8. Witkin, H.A., et.al. (1971) Manual, Embedded Figures Test. Palo Alto, CA: Consulting Psychologists Press, Inc.

9. Dwyer, F.M. (1978) Strategies for Improving Visual Learning. State College, PA: Learning Services.

Finding One's Way in Electronic Space:
The Relative Importance of Navigational Cues and Mental Models

Stephen T. Kerr

Professor of Education

University of Washington

Address: 412 Miller Hall, DQ-12
University of Washington
Seattle, WA 98195
BITNET: D0960 @ UWACDC

Paper Presented at the Annual Conference of the

Association for Educational Communication and Technology

Atlanta, Georgia

February, 1987

ABSTRACT

Difficulties with "wayfinding" are common among users of electronic information systems. A study of strategies (textual, graphic, color) to cue users to their location in a database showed that the presence or absence of physical cues was less important to successful searching than the user's ability to represent internally the structure of the information. Users with more detailed and complete representations of the information searched faster and made fewer wrong turns. But the variety of different representations of the database suggest it may be very difficult to create generic models as a help to novice users.

Finding One's Way in Electronic Space:

The Relative Importance of Navigational Cues and Mental Models

The rapid spread of electronic databases raises a set of perplexing questions for researchers and designers concerned with how information may best be structured and displayed. One the one hand, there is the attractiveness of being able at last to create interactive resources of considerable size and sophistication; the ability to provide 54,000 still images on a videodisc or 250,000 pages of a major encyclopedia on a CD-ROM are encouraging many to undertake design work using interactive databases. On the other hand, there are suggestions that naive users may have difficulty acquiring the skills necessary to navigate in such large seas of data. The system of cues and information that guide the user of a database to desired information and that allow the user to navigate from that information, once found, to other parts of the database is what I call a "wayfinding system." What kinds of cues can help to make such a system efficient, and the influence on wayfinding ability of a user's own model of system structure and function, are the topics for examination here.

Background: From Print to Screen

The Psychological Heritage of Print

Our ways of working with printed materials are so closely interwoven into our unexamined view of how information should be organized that it is very difficult to step back and see clearly just how much we take for granted. The "metastructure" of printed material is an integral part of our 500-year experience with print (Febvre & Martin, 1976). Page numbers, title pages, chapter titles, line leading, headings, tables of contents, indexes, appendices, footnotes and references--all help us find what we want and locate ourselves with respect to other material. We often forget, however, that these aids did not all come into being with the advent of printing but rather had to be individually invented and accepted. The pace of development may be more rapid now, but the conceptual problems are no less severe when we move to electronic systems for storing and retrieving information.

Aspects of Electronic Wayfinding

The metastructure of electronic text is not parallel to that of print. Indexes and tables of contents give way to hierarchical database structures or keyword searching. Chapter headings and other cues on the page are supplanted by icons and on-screen menus. We know more about some of these aspects of the metastructure of electronic text than about others. For example, on the level of the individual screen, we know something about menu formats: users seem to prefer and work more effectively with "broad" menus that present medium or large numbers of choices on each screen (Lee & MacGregor, 1985).

But menus have problems: many errors occur at the initial menu level (where users are least likely to know what categories are subsumed under the top-level items; in one study, 18% of all search time was spent using the top-level menu [Irving, Elton, & Siegeltuch, 1982]). Users may also become frustrated by working up and down through layers of menus without finding desired information; in one study, 28% gave up even though they knew that "the information is in there somewhere" (Latremouille, Mason, McEwen, Phillips, & Whalen, 1981). And 50% of users of a menu-based system had to backtrack at least once before finding information they wanted (Carey, 1981).

Keywords are helpful to more experienced and frequent users, but are less useful for occasional users (Geller & Lesk, 1982; Shneiderman, 1982). There may in fact be little objective reason to prefer keywords over menus, since users' problems often lie in realms other than the mechanics of access (Van Nes & Van der Heijden, 1982).

Icons have also attracted attention as wayfinding aids, but validating their usefulness empirically has been a problem (Mackett-Stout & Dewar, 1981). Some have suggested that learning to use an icon-based system may be no easier--just different--than learning one based on text or menus (Samet, Geiselman, & Landee, 1982). Color also may be an effective cue, and while its use is rarely perceived as mandatory (e.g., Tullis, 1981), color is an "attractive nuisance"--a feature that users will consistently ask for and claim to like, even if it adds nothing to performance (Christ, 1975; Reynolds, 1979).

On the level of the document or database, a number of navigation methods remindful of print have been proposed (Benest & Potok, 1984; Engel et al., 1983; Lochovsky & Tsichritzis, 1981; Spence & Apperley, 1982). Some of these use on-screen menu-plus-text systems to allow the user to keep track of present location, and to permit retracing steps through previous menus to an earlier point. None of these systems, however, has gained general acceptance. And because making wayfinding information accessible also implies making it visible, these approaches all quickly encroach on limited screen space.

Several studies have concluded that design for electronic information must not focus merely on specification of mechanical aspects of the interface. Rather, the most critical element may be to understand how the user conceptualizes the material at hand--what categories it contains, how it is organized, and so on (Hills, 1983; Vigil, 1983). Waern and Rollenhagen (1983) observe that we know little about how to capitalize on metacognitive processes (setting goals, planning, recognizing problems) in using electronic text.

The Value of Cues in Wayfinding: A Study

Method

A study was done to determine the effectiveness of various methods of cueing users as to their location in a videotex information system (full report: Kerr et al., 1985). Using VAST, a PC-based videotex frame creation and database management system, five different versions of a database (an electronic edition of a college catalog) were created: "Simple" (no cues), "Headers" (textual cues), "Color" (color cues), "Icons" (graphic cues), and "Fancy" (textual, color, and graphic cues).

The subjects were 99 graduate students at a large urban graduate school of education and human services. Prior to the experiment, subjects were asked to complete a brief questionnaire on their background, employment, and previous experience with computers (especially databases and on-line information retrieval systems). The subjects were then asked to work with the electronic catalog to complete ten search tasks.

Tasks typically required that the user search through three to five levels of menus; some searches required scrolling through multiple frames making up a single "page" of information. The Ss were videotaped as they worked; the information thus gathered was coded for time, number of false turns during searches, and number of right and wrong answers found. A post-questionnaire requested that Ss make an assessment of the ease of using the database and the degree of satisfaction in using it; experimenters also asked the Ss for their perception of the usefulness of the various cues.

Follow-up interviews were conducted with 50 Ss (ten per condition) six weeks after the initial experimental trials. Interviewers inquired about Ss' memory of the database, the cues incorporated in it, the structure of the database, the content of the search tasks, and perceived satisfaction with/ease of using the database at that point.

peed, Efficiency, and Accuracy Effects

Table 1 summarizes the main quantitative results of the study. There were no significant differences among groups in the speed with which subjects completed the search tasks ($F[4,96] = .745$, $p > .5$), in their efficiency (choice of a search path involving a minimal number of screens; $F[4,96] = 1.759$, $p > .1$), or in their accuracy (ability to find the correct answer on the first try; $F[4,96] = .213$, $p > .9$). In fact, when the index of previous computer use was introduced as a covariate, it accounted for significantly more variation than the cueing conditions for both speed ($F[1,96] = 7.788$, $p < .01$) and efficiency ($F[1,96] = 5.021$, $p < .03$).

Table 1 here

Awareness of Cue Function and Use in Navigation

Since subjects were not informed at first of the function of the various cueing conditions, they were asked at the conclusion of the experiment if they had in fact been aware of the cues, if they were aware of the function of the cues, and if they had actually used the cues when navigating in the database. Two measures appear in the following analyses: *cue awareness*--a simple rating of how aware the subject was of the cue's function (ranging from 0, not at all aware, to 2, fully aware), and *cue* use--a composite index of cue-use-in-navigation. This included the subject's awareness of the existence of the cues, the awareness rating (as above), and a measure of the extent to which the subject claimed to have used the cue for navigation. To stress actual use of cues for navigation (rather than simple awareness), the last of these components (cue use in navigation) was weighted 3 times as heavily as simple awareness of the cue itself, and 1.5 times as heavily as awareness of the cue's function.

Note that in the analyses that follow, data for subjects who used the "Simple" (no cues) database are ommitted. There were no cues in that database, and therefore those subjects were not asked about their awareness of cues or use of them.

Awareness of cue function. An analysis of variance for these data showed significant differences among cell means, F (3,78) = 6.556, $p < .001$. A multiple classification analysis showed that about 21% of the variance in awareness is accounted for by the cue differences. Further, a Tukey HSD multiple range test shows that the cueing conditions can be clustered with "Color" and "Fancy" in one subset, and "Fancy," "Headers,"and "Icons" in a second subset. This further suggests that "Color" on the one hand, and "Headers" and "Icons" on the other, do in fact differ in terms of subjects' awareness of the function of those cues as navigational aids.

Table 2 here

Use of cues for navigation. As with simple awareness of cue function, the data for navigational use of cues were subjected to analysis of variance. The results are shown in Table 3.

Table 3 here

Once again, the differences among the various cell means are significant, F (3,78) = 5.833, $p < .001$. The effect of cueing condition is slightly less powerful here, but still explains almost 19% of the variance. A Tukey HSD multiple range test shows that the groups can be clustered with "Color" and "Fancy" in one subset, "Fancy," "Icons," and "Headers" in another subset. As above, this suggests that "Color" differs significantly (in a negative direction) from both "Icons" and "Headers" in terms of its attractiveness to users as a wayfinding aid.

What might explain these differences in both awareness of cues' navigational potential and actual cue use? Certainly we could hypothesize that subjects would pay more attention to the graphic icons. They are simply more novel than color alone. Color on a video screen has become so commonplace in most peoples' daily lives that it may no longer arouse great interest. Graphics, however, probably have more residual power in that they may match in their outline, "broad brush" form the kinds of mental schemata that people create to identify categories internally. Textual header lines, however, may generate more awareness simply because people are used to using such devices as wayfinding tools.

Section summary. Subjects differed, therefore, in their awareness of the cues and the function of those cues. Color cues seemed less impressive than textual or graphic cues and subjects also said that they used color cues less frequently in searching. Perhaps color has, through intensive use on video in general, lost some of its power as a cue; text is commonly used in this sort of environment as a cue; graphics may both be novel to many users and also match (or aid in constructing) an internal schema of how the database is organized.

Perceived Ease, Satisfaction, Memorableness

In this study, differences between conditions in the levels of ease and satisfaction perceived by subjects in their searching operations were also of interest. In other words, regardless of the length of time subjects took searching or the number of errors subjects actually made, did they think that the experience of searching was a satisfying one, and did they subjectively find the database easy to use. To investigate these questions, subjects were asked to rate their experience (in terms of both ease of use and satisfaction) on a 7-point Likert scale immediately after they completed the search tasks.

As part of the follow-up study, subjects were again asked to rate their experience with the database. We thus were able to determine whether there were differences in users' subjective experiences immediately following searching or in reflection on looking back at their work several weeks later.

An additional set of questions revolved around the issue of memorableness. We were concerned to discover whether there were any differences among users in terms of their recall for a number of aspects of the database and the user interface. Among the variables that we asked about in the follow-up were: numbers of screen attributes recalled, memory of specific search tasks, number of questions or tasks recalled, recall of the main menu categories, and the type of language used by the subjects in describing the database. Only some of these data are discussed here.

Immediate ease/difficulty in using the database. There were no great differences among the conditions in subjects' immediately expressed reactions to the ease or difficulty of using the database. Means for the groups are shown in Table 4.

Table 4 here

The group means are not significantly different one from another, F (4,98) =

Immediate satisfaction in using the database. Here again, there were no large differences among the groups in their subjective satisfaction with using the database. The means for the five groups are presented in Table 5.

Table 5 here

As above, an analysis of variance does not show any significant differences among the groups, F (4,98) = .373, p > .8.

While there are no significant differences here, it is worth noting that there is a consistent *irection*in the findings. Subjects using database "Fancy" showed the highest ratings for both ease of use and satisfaction.

Recalled ease/difficulty in using the database. Interestingly enough, there are some significant differences in the data for subjects' *recalled* ease or difficulty in using the database. Table 6 shows cell means.

Table 6 here

These data indicate a significant difference between groups, F (4,48) = 5.438, p < .001. Those who used database "Headers" gave quite low ease-of-use ratings compared with other groups. Those who used "Color" were generally more positive. A Tukey HSD multiple range test showed that "Headers" and "Icons" are in one subset, while "Icons," "Simple," and "Color" are in another. Subjects recalling their experiences with "Headers" are at least distinct from those remembering their work with "Simple," "Fancy," and "Color."

Why should this be? The results would be less puzzling if we had found "Simple" off by itself at the low end in recall. Then one might have been able to argue that it was the unhelpful quality of the interface that led to the decline in evaluation of this database by its users. But "Headers" has information for users--note that subjects in "Headers" claimed to have been aware of the function of and to have used those textual cues more than did users of some other cues. Perhaps it is the case that "Headers" is simply too prosaic, and that users of "Simple," for example, remembered the experience as more of an "adventure game"--moving off into uncharted electronic space with no map or compass.

Recalled satisfaction in using the database. Again here some differences appear among the various groups in their recalled satisfaction in using the database. The cell means are displayed in Table 7.

Table 7 here

As was the case with the data on recalled ease-of-use, users of "Headers" were more negative about their remembered satisfaction in using the database, while those who used "Fancy" were most positive. The ANOVA results are ambiguous--F (4,48) = 2.242, p = .08. Additionally, a multiple range test here shows no differences between subsets of groups. Nonetheless, with 17% of the variance in recalled satisfaction explained by the differences in cueing conditions, the possibility exists that these differences are worthy of further consideration.

Recall of specific database attributes. The follow-up study asked subjects to recall a number of attributes of the database and the search tasks: specific aspects of the screen design, the search tasks themselves, and the categories used on the main menu of the database. We also asked the subjects to describe the database, and coded their responses for the type of metaphorical or figurative language used in their descriptions. Only information on the recall of numbers of attributes is presented here.

There were some differences among the groups in terms of the number of screen attributes recalled. (Screen attributes included such aspects of screen design as specific text, placement of text, shape of border polygons, bottom prompts, and the cues themselves.) The results are shown below in Table 8.

Table 8 here

There is a curious aspect to these findings. In examining the group means, note that users of "Color" recalled the largest number of screen attributes, while those who used "Headers" recalled the fewest. While the sigificance of the results is ambiguous--$\underline{F}$ (4,48) = 2.535, $\underline{p} < .06$--they are in a direction that might have been assumed. Research on instructional film and television has shown that use of color tends to promote the recall of unrelated peripheral details, and perhaps the effect here is a parallel one.

How are we to explain the apparent lack of memorableness of the interface design of the "Headers" database? Perhaps the use of textual headers turns the task into one of tracking one's way through a textual manual. "Headers" subjects claimed to have been more aware of the function of their cues and also to have used the cues more for navigational purposes. This suggests that users of a textually-cued database might see consulting that database as more of a dull, routine task--fairly easy to do, but more like other text-oriented tasks that are encountered all the time in our contemporary textually influenced life. Perhaps, then, those who use databases cued by icons see the task as more of a "computer game," a situation to be explored, an environment to be sensually savored.

Section summary. Subjects did not differ in their immediate perception of the ease of using the database or on their satisfaction with it. On later reflection, however, users of textual cues were significantly more negative about the ease/difficulty of the experience, while those using color cues, all cues, or no cues were more positive. Users of the color-cued database also recalled significantly more screen attributes, while those using textual cues recall fewer. It may be the case that textual cues remind users of other types of information-search tasks that are typically accomplished using textual cues (working with an encyclopedia or dictionary, for example), while those who use color or iconic cues may see the exercise as one more like a computer game.

Subjects' Conceptualizations of the Database

At the conclusion of the experimental session, subjects were asked to "give us your impression" of the database. The request was purposely phrased in such a way that Ss would not necessarily take the task as being "write a description of the database" or "draw a diagram of the database." The impressions were coded as basically verbal, basically graphic, or a combination of the two.

Impressions of database structure. When asked to give a representation of the structure of the database, faster users generally gave more detailed, more graphic impressions. Slower users gave simpler, more verbal descriptions. A number of themes emerged in the impressions: "tree" and "pyramid" metaphors, "book" language and descriptions, and other descriptions that made the analogy to filing cabinets or loose-leaf notebooks. These findings are particularly interesting and warrant further examination here.

Faster and slower searchers' impressions. There were correlations between the complexity (amount of detail and use of graphic elements) in subjects' impressions and speed (r = -.18) and efficiency (r = -.06), with more accurate, efficient searching associated with more detailed impressions. While these are not strong relationships, the consistency in direction of the figures suggests that subjects who move through the database more rapidly or with fewer problems may have a more articulated internal representation of how the database is structured.

Some of the representations of subjects who searched faster and slower are shown here. Figures 1 through 3 are the representations of the three fastest subjects; their total search times range from 590 to 684 seconds. Figures 4 through 6 show the impressions of the slowest subjects, with search times ranging from 2685 to 2870 seconds.

Figures 1-3 here

The faster users tend to have more graphically detailed representations. All of these subjects provided what was basically a sketch of the tree structure of the database. One subject (58) realized that some information was shared across categories, although this was never explicitly brought to the subjects' attention.

Figures 4-6 here

Among the slower subjects, the representations tend to be more verbal. They also show the seemingly greater naiveté of these users. Subject 9, for example, indicates that while this "was a wonderful machine," that it would likely be easier to use after having "been exposed to it for awhile." A similar theme is sounded by subject 38--"I am not used to computers." The impression of Subject 62 was basically graphic, but not as comprehensive as some of the faster searchers' sketches.

The representation of another slow searcher (32, Figure 7) is a puzzle here, for s/he had had previous experience with a database system at an insurance company. Perhaps the slower search time was due to the need to learn a new system that was similar (but not identical) to a known one. This is a problem we shall return to below.

The existence of a slight correlation between complexity of representation and efficiency in searching may not be the most important of these findings. What stands out above is the diversity in ways of modeling a structure of electronic information. There may in fact be underlying elements that repeat from one model to another, but the surface differences suggest that caution is in order if we attempt to create one sort of mental model with which to initiate novice computer users.

The Centrality of User Understanding

A shift away from concern with mechanical aspects of the interface and toward developing a better picture of how users understand the workings of computer systems is visible in much recent work in the field of human factors and human-computer interaction. Users' understandings, explanations, and representations may be seen as aspects of mental models that users must create and bring to bear as they work in electronic environments. (See, for example: diSessa, 1986; Gentner & Stevens, 1983; Lewis, 1986; Mark, 1985; Quinn & Russell, 1986; and Suchman, 1985.)

Users' mental models are probably most important when the user first learns how to work with a system, or when the user returns to working with it after a long hiatus (Norman, 1986). This raises a set of interesting questions, for research in educational technology suggests that while one can train people to use a particular mental model in addressing a particular task, this may not always be the best thing to do. People differ in their abilities to figure out appropriate models for themselves, and supplying a new model to someone who already has a satisfactory internal understanding of how to solve the problem may actually interfere with that understanding. On the other hand, supplying a model may be very efficient when the user is not capable of generating an internal model of how to proceed (Salomon, 1979).

Other work on the generation and use of mental models may provide some assistance here. In a study of how learners approach a material assembly task by Baggett and Ehrenfeucht (1985), "typical" and "minority" conceptualizations of the task were first identified, then used to instruct naive subjects to perform the task. The authors found that "people studying typical instructions yield typical conceptualizations [of their own], and importantly, people studying minority instructions also yield typical conceptualizations, although they are significantly less typical than those from typical instructions" (p. 2). The authors could not decide whether this was a result of some subjects' simply ignoring the minority model, or whether such models competed with some persons' "typical" model.

In another study, closer in focus to the work discussed here, Borgman (1986) found that providing a conceptual model of the functions of an online information system helped subjects more with complex tasks requiring extrapolation than it did with routine search tasks. But Borgman, while noting that subjects had difficulty articulating their models of system function, did not attempt to provide alternative models or to identify individual differences on which such models might be based.

What is needed at this point is more empirical testing of the value of supplied vs. internally constructed models of system functioning and information structure for both naive and sophisticated users of computer systems. Are there, for example, low levels of system use at which it will simply make sense to provide a model of the system's function and structure even though that model may interfere with an individual's "natural" or preferred way of representing the system internally? Are there long-term problems in efficiency or satisfaction with system use that arise as naive users with a supplied model employ a system more frequently and in a more sophisticated way? And does variation in models reflect only surface differences, or are there in fact underlying distinctions to which we should pay attention? As computer systems become more complex and as the number of users to be trained on them increases, finding where supplied models are useful and where they are not is a question that will continue to have both theoretical and practical importance.

References

Baggett, P., & Ehrenfeucht, A. (April, 1985). Conceptualizing in assembly tasks. Technical Report No. 139. Boulder, CO: University of Colorado, Institute of Cognitive Science.

Benest, I., & Potok, M. (1984). Wayfinding: An approach using signposting techniques. Behaviour and Information Technology, 3(2), 99-107.

Borgman, C. (1986). The user's mental model of an information retrieval system: An experiment on a prototype online catalog. International Journal of Man-Machine Studies, 24, 47-64.

Carey, J. (1981). Human factors in videotex. Bronx, NY: Greystone Communications.

Christ, R. (1975). Review and analysis of color coding research for visual displays. Human Factors, 17, 542-570.

diSessa, A. (1986). Models of computation. In D. Norman & S. Draper (Eds.), User Centered System Design. Hillsdale, NJ: Lawrence Erlbaum Associates (pp. 201-218).

Engel, F., et al. (1983). What, where, & whence: Means for improving electronic data access. International Journal of Man-Machine Studies, 18, 145-160.

Geller, V., & Lesk, M. (1982, October). How users search: A comparison of menu and attribute retrieval systems in a library catalog. Paper presented at the annual meeting of the ASIS, Columbus, Ohio.

Gentner, D., & Stevens, A. (Eds.) (1983). Mental models. Hillsdale, NJ: Lawrence Erlbaum Associates.

Hills, P. (1982). Human communication and information technology. In P. Hills (Ed.), Trends in information transfer. Westport, CT: Greenwood Press.

Irving, R., Elton, M., & Siegeltuch, M. (1982). The last five months of a pilot teletext service: Interim results on utilization and attitudes. Research on broadcast teletext: Working paper No. 7. New York: New York University, Alternate Media Center.

Kerr, S., Rosenblad, K., Phillips, M., Carlin, T., Hermann, J., Levine, G., & Schimmel, B. (1985). Empirical tests of videotex wayfinding aids. Final report. (IBM Research Division Contract No. 466014.) Seattle, WA: University of Washington.

Latremouille, S., Lee, E., Mason, C., McEwen, S., Phillips, D., & Whalen, T. (1981). The design of videotex tree indexes. Telidon behavioural research No. 2. Ottawa: Department of Communications.

Lee, E., & MacGregor, J. (1985). Minimizing user search time in menu retrieval systems. Human Factors, 27(2), 157-162.

Lewis, C. (1986). Understanding what's happening in system interactions. In D. Norman & S. Draper (Eds.), User Centered System Design. Hillsdale, NJ: Lawrence Erlbaum Associates (pp. 171-185).

Lochovsky, F., & Tsichritzis, D. (1981). Interactive query languages for external databases. Telidon behavioural research No. 5. Ottawa: Department of Communications.

Mackett-Stout, J., & Dewar, R. (1981). Evaluation of symbolic public information signs. Human Factors, 23, 139-151.

Mark, W. (1985). Knowledge-based user interface design. Human-Computer Interaction, 1(4), 339-357.

Norman, D. (1986). Cognitive engineering. In D. Norman & S. Draper (Eds.), User Centered System Design. Hillsdale, NJ: Lawrence Erlbaum Associates (pp.

Quinn, L., & Russell, D. (1986). Intelligent interfaces: User models and planners. In M. Mantei & P. Orbeton (Eds.), Human factors in computing systems. ACM SIG CHI 1986 Proceedings. New York: Association for Computing Machinery (pp. 314-320).

Reynolds, L. (1979). Teletext and viewdata--A new challenge for the designer. Information Design Journal, 1(1), 2-14.

Salomon, G. (1979). Interaction of media, cognition, and learning. San Francisco: Jossey-Bass.

Samet, M., Geiselman, R., & Landee, B. (1982). A human performance evaluation of graphic symbol-design features. Perceptual and Motor Skills, 54(3, part 2), 1303-1310.

Shneiderman, B. (1982). The future of interactive systems and the emergence of direct manipulation. Behaviour and Information Technology, 1(3), 237-256.

Spence, R., & Apperley, M. (1982). Database navigation: An office environment for the professional. Behaviour and Information Technology, 1(1), 43-54.

Suchman, L. (1985). Plans and situated actions: The problem of human-Machine communication. (Technical Report No. ISL-6.) Palo Alto, CA: Xerox Palo Alto Research Center.

Tullis, T. (1981). An evaluation of alphanumeric, graphic, and color information displays. Human Factors, 1981, 23(5), 541-550.

Van Nes, F., & Van der Heijden, J. (1982). On information retrieval by inexperienced users of databases. IPO International Progress Report, 17, 129-137.

Vigil, P. (1983). The psychology of on-line searching. Journal of the American Society for Information Science, 34(4), 281-287.

Waern, Y., & Rollenhagen, C. (1983). Reading text from visual display units (VDUs). International Journal of Man-Machine Studies, 18, 441-465.

Table 1

Effect of Cues on Speed, Efficiency, Accuracy of Search
(Cell Means--by Cueing Condition)

CONDITION	Simple (N = 20)	Headers (N = 19)	Color (N = 19)	Icons (N = 19)	Fancy (N = 20)	GRAND MEAN (N = 97)
Speed (Seconds)	805.50	957.37	924.47	1057.32	861.80	919.48
Efficiency (Number of Screens Accessed)	31.2	30.16	37.47	43.16	25.00	33.29
Accuracy (Correct Answers on First Try)	8.55	8.68	8.26	8.63	8.45	8.52

Table 2

Cell Means for Awareness of Cue Function across Cueing Conditions

CONDITION Headers	Color	Icons	Fancy	GRAND MEAN
1.25 (20)	.40 (20)	1.47 (19)	1.05 (20)	1.04 (79)

Table 3

Cell Means for Navigational Use of Cues across Cueing Conditions

CONDITION Headers	Color	Icons	Fancy	GRAND MEAN
3.15 (20)	1.25 (20)	2.79 (19)	2.35 (20)	2.38 (79)

Table 4

Cell Means for Immediate Ease/Difficulty in Using the Database
(Range: 10 = low; 70 = high)

CONDITION

Simple	Headers	Color	Icons	Fancy	GRAND MEAN
58.75	54.75	55.50	57.26	59.50	57.15
(20)	(20)	(20)	(19)	(20)	(99)

Table 5

Cell Means for Immediate Satisfaction in Using the Database
(Range: 10 = low; 70 = high)

CONDITION

Simple	Headers	Color	Icons	Fancy	GRAND MEAN
55.50	55.25	54.50	53.16	58.00	55.30
(20)	(20)	(20)	(19)	(20)	(99)

Table 6

Cell Means for Recalled Ease/Difficulty in Using the Database

CONDITION

Simple	Headers	Color	Icons	Fancy	GRAND MEAN
54.00	39.50	58.60	51.11	54.00	51.45
(10)	(10)	(10)	(9)	(10)	(49)

Table 7

Cell Means for Recalled Satisfaction in Using the Database

CONDITION

Simple	Headers	Color	Icons	Fancy	GRAND MEAN
48.00	43.00	55.00	56.67	58.00	52.04
(10)	(10)	(10)	(9)	(10)	(49)

Table 8

Cell Means for Number of Screen Attributes Recalled

CONDITION

Simple	Headers	Color	Icons	Fancy	GRAND MEAN
3.30	2.10	4.10	2.44	3.80	3.16
(10)	(10)	(10)	(9)	(10)	(49)

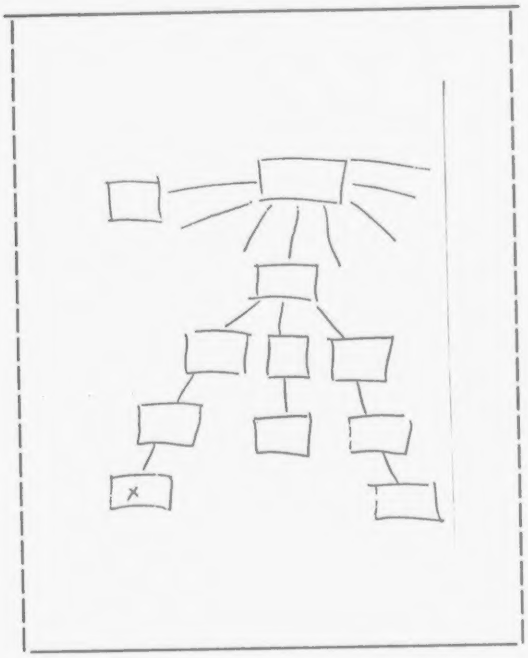
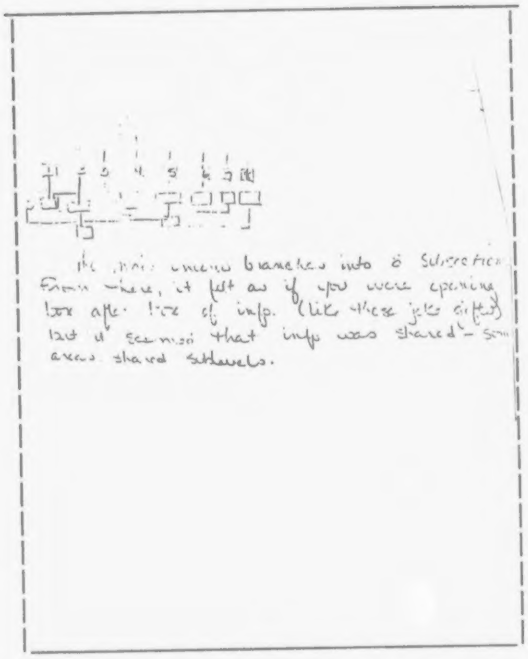


Figure 1
(Subject 33; 590 secs.)



The main menu branches into 8 subsections. From there, it felt as if you were opening box after box of info. (like these [illegible]) but it seemed that info was shared — some areas shared sublevels.

Figure 2
(Subject 58; 668 secs.)

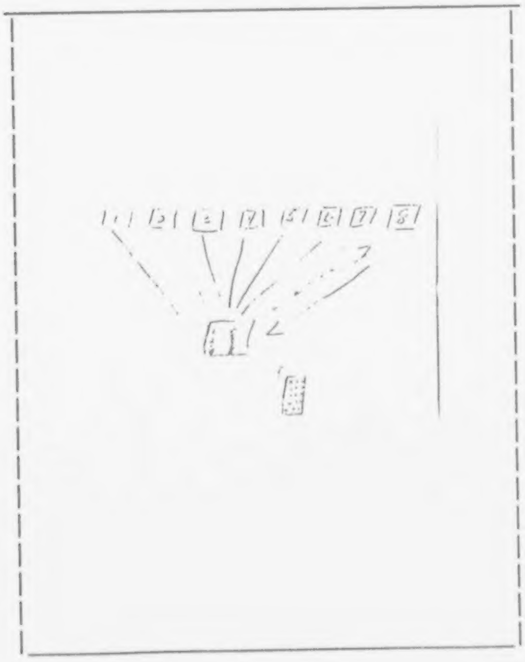


Figure 3
(Subject 25; 684 secs.)

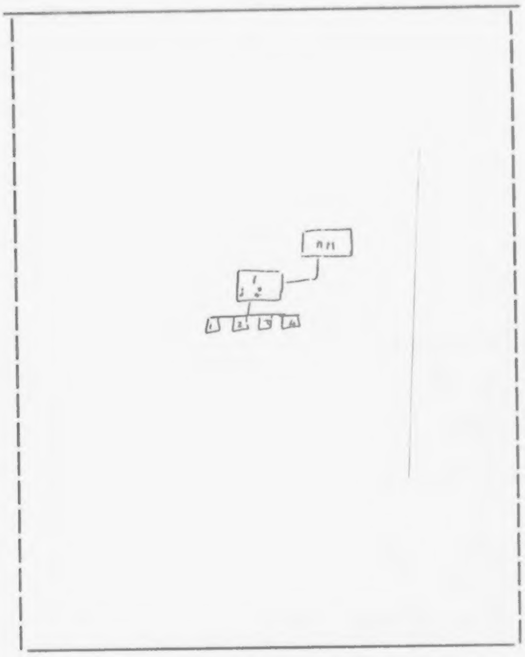
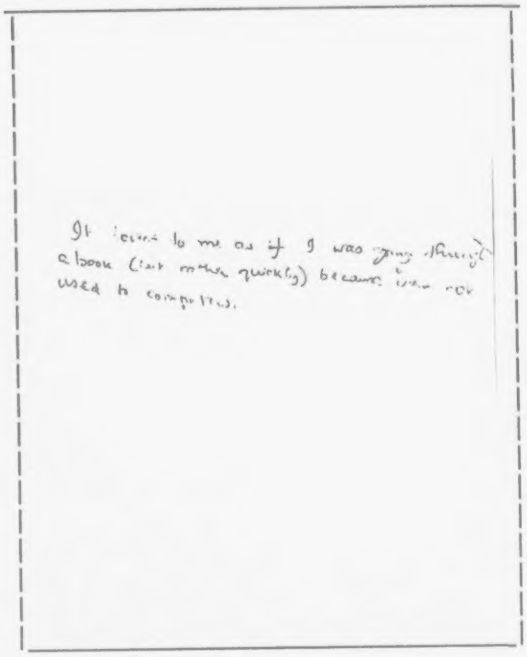
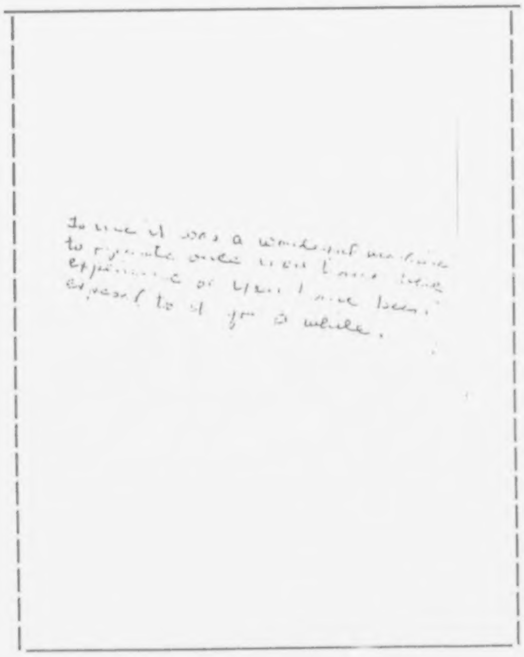


Figure 4
(Subject 62; 2685 secs.)



It seems to me as if I was going through a book (but rather quickly) because I was not used to computers.

Figure 5
(Subject 38; 2753 secs.)



To me it was a wonderful machine to [illegible] [illegible] [illegible] I have [illegible] experience or years I have been exposed to it for a while.

Figure 6
(Subject 9; 2870 secs.)

A Comparison of a Microcomputer Progressive State Drill and Flashcards for Learning Paired Associates

James D. Klein
Center for Needs Assessment and Planning
Florida State University
Tallahassee, FL 32306

David F. Salisbury
Center for Educational Technology
Florida State University
Tallahassee, FL 32306

Running head: PROGRESSIVE DRILL

Abstract

Among the uses of the computer in education, drill and practice ranks as one of the most popular. Yet, in spite of the pervasiveness of these drills, relatively few studies have been done to compare the effectiveness of various computer-based drill strategies with each other or with other methods of practice. This study compares the effectiveness of learning paired associates from a computer-based drill strategy known as the *progressive state drill* with the effectiveness of having students use their own strategies with flashcards. The progressive state drill is a fairly sophisticated drill structure which includes several characteristics which make it appear to be a potentially effective drill and practice strategy for learning paired associates. Some of these characteristics include: use of a small working pool of items, increasing ratio review, dynamic adjustment of the drill based on student performance, and record keeping from session to session. Results, however, failed to show any superiority on a posttest achievement measure for the progressive state drill over the flashcard approach. There was a difference in attitude of the two groups toward the instruction, with the microcomputer group demonstrating a significantly more positive attitude. Implications for design and use of microcomputer drills such as the progressive state paradigm are discussed.

A Comparison of a
Microcomputer Progressive State Drill and
Flashcards for Learning Paired Associates

Computer drills are becoming more and more popular. Various computer-based drill and practice strategies have been described in the literature (Allesi and Trollip, 1985; Atkinson, 1974; Merrill & Salisbury, 1984; Salisbury, in press; Seigal & Misselt, 1984). Usually these computer-based drill strategies are compared with simple flashcard strategies to show their superiority. However, few studies have been done to compare these various strategies with one another or to compare the effect of learning from a particular computer-based drill strategy with the effect of having students use their own strategies with flashcards.

The purpose of this study was to compare the effectiveness of a computer-based drill strategy known as the progressive state strategy with the effect of having students learn the same material using their own strategy with flashcards. The study examined the effect of the progressive state drill on student post-test performance and attitude toward the instruction. The post-test performance and attitude of a group of subjects who tried to learn the content by means of the progressive state drill were compared against the same measures of a group of subjects who tried to learn the content by using their own strategy with flashcards.

Description of the Progressive State Drill Strategy

The progressive state drill strategy includes several characteristics which make it potentially effective. Some of these are: (a) use of a small working pool of items, (b) an increasing ratio review schedule, (c) dynamic adjustment of the drill based on student performance, and (d) record keeping from session to session. The term progressive state is used to describe the drill since items are presented to the learner in a progressive sequence passing from one presentation state to another based on performance criteria for each state. Box 1 shows a flowchart for a progressive state drill. In this drill items are presented in six different states. These are:

1. Pretest state - used to determine if the learner already knows the item

2. Rehearsal state - presents item and response simultaneously on the screen for a brief moment to allow learner to associate them together. The learner is then asked to type in the correct response.

3. Drill state - presents the item and prompts learner for correct response

4. First Review state - identical to how item was presented in drill state

5. Second Review state - same as first review state

6. Third Review state - same as first review state

- - - - - - - - - - - - - - - - -

Insert Box 1 about here

- - - - - - - - - - - - - - - - -

Each item in the drill has a state number associated with it. This state number indicates the current state of the item and determines the presentation state in which the item will be presented. When the learner begins a practice session any items left in the learner's working pool from the last session are transferred from the disk to the current working pool (Step 1). Review dates and state numbers corresponding to each of the items are also transferred from the disk. If the working pool is not full, then additional items are selected from the review pool if there are any review items which have review dates less than or equal to today's date (Steps 3 and 4); otherwise additional items are selected from the new item pool (Step 5). After the working pool is shuffled (Step 6), the first item is selected and its state noted (Steps 7 and 8). If the item has just entered the drill as a new item, it will be presented as a pretest item (State 1). If the learner responds correctly to the item, it will be deleted from the system. Otherwise, its state will be updated to State 2. The value of the item counter (N) is then incremented, and the second item from the working pool is selected (Step 7 again). This item is presented in accordance with its specified state. After all the items in the current working pool have been presented once (N 7), the working pool is replenished and shuffled (Steps 1 - 6), and the item counter (N) is set back to 1 (Step 7). This process is repeated until the learner terminates the practice session. Note that after an item is presented in State 3 (drill), it is removed from the working pool and transferred into the review pool. The review pool is divided into three states to provide increasing ratio review.

Simply stated, increasing ratio review means that new and review items will be intermixed throughout the drill with the ratio of review to new items increasing as the drill progresses. When the learner first begins the drill, all items will be new items. As the learner masters items, these become review items and are reintroduced systematically into the drill based on time elapsed since the learner was last presented that item. Toward the end of the drill most of the items will be review items with only a few new items being introduced.

Drills which are structured in this way are very useful for the purpose of skill maintenance in addition to initial learning. Learners can work on the drill initially to master the content and then they can continue to use the drill from time to time to review and re-check mastery. Typically, once a person has attained a high level of accuracy and precision on a skill, it can be maintained at that level over a long period of time with only a small amount of practice at regular intervals.

In order to construct a drill with increasing ratio review it is necessary that each item in the review pool have a review date associated with it. This review date indicates when the item is next to be reviewed. When the learner begins a practice session, any items left in that learner's working pool from the last session are transferred from the disk to the current working pool. The working pool is shuffled and the items in the working pool are presented to the learner. If the learner gives a correct response to an item the item goes into the review pool. If an incorrect response is given the item remains in the working pool. Steps 3-5 of Box 1 show how the working pool is replenished. The procedure first checks to see if there are any items in the review pool which are ready for review (Steps 3 and 4). An item is ready for review when its review date is equal to or less than the current date. Otherwise, the replacement item is a new item from the item pool (Step 5).

Hypothesis

The presence of the desirable instructional characteristics of the progressive state drill mentioned above (small working pool, increasing ratio review, dynamic adjustment of the drill based on student performance, and record keeping from session to session) give reason to believe that students using this drill might perform better on a post-test than students using their own strategies with flashcards. However, there is also a theoretical basis to suggest the flashcard group might learn better than students using the progressive state drill. The basis for this arises from cognitive learning research which suggests that students learn verbal information by paying attention to the "meaning" of the material and organizing structural representations of the material in their minds (Anderson, 1980; Salisbury, 1984; Salisbury, Richards, & Klein, 1985). To promote the formation of these structural representations, students should be able to identify important relationships, sequences, or groups present in the material. The progressive state drill paradigm, like most other computer-based drill paradigms, presents only one item at a time to the student, making it difficult for the student to form his or her own groupings or sequences. In contrast, with flashcards, students can lay out several flashcards on the table to form groups and they can group them any way they wish. Pilot research done by the experimenters suggested that with learners who have fairly well developed study strategies, the flexibility of flashcards provides an advantage over a structured computer-based drill such as the progressive state drill. Since a theoretical base existed to suggest the possible superiority of either group, a two-tailed statistical test was chosen. The hypothesis (stated in the null form) was that there was no statistically significant difference in learning between the PSD group and the flashcard group. A second null hypothesis was that there was no statistically significant difference in attitude toward the instruction between the two groups.

Design

This study utilized a statistical methodology known as sequential analysis (King & Roblyer, 1984; Weed & Bradley, 1971). In sequential analysis the sample size for an experiment is not specified in the research design. Instead, certain decisions are made by the investigator prior to the collection of data. The characteristics of these data as they are obtained and analyzed determine the point at which the number of observations is sufficient for the experiment to be terminated.

In a sequential analysis study, a set of observations is obtained and the data from this first set of observations is analyzed. Based on the results of this and any prior observations, one of three decisions is made: (a) accept the null hypotheses, (b) accept an alternative hypothesis, (c) or obtain more observations. The principal advantage of sequential analysis over designs which specify a fixed sample size is its greater efficiency. Since, in sequential analysis, data are analyzed as they are obtained, it is often the case that decisions can be reached with fifty percent or fewer observations than would be possible with other types of research designs.

Method

The task consisted of learning 100 word-number pairs which were unfamiliar to the subjects. Examples of word-number pairs are 1 - HAT, 10 - TOES, 30 - HEAD. The complete set of 100 items is shown in Figure 1. Subjects were high school sophomores from the Developmental

- - - - - - - - - - - - - - - - - -

Insert Figure 1 about here

- - - - - - - - - - - - - - - - - -

Research School at Florida State University. Ninety-six potential subjects were pretested using the Object-Number Test developed by Educational Testing Service (1963) as a measure of their ability to remember word-number pairs of the type that were to be employed in the study. Subjects were placed into matched-pairs based on their pretest scores and one member of each pair was randomly assigned to either the group using flashcards or to the microcomputer group.

The treatment consisted of three twenty minute sessions, one session each day for three consecutive days. Subjects in the flashcard group were allowed to use the flashcards in any manner they wished but were required to work alone. Subjects in the microcomputer group used the progressive state drill to learn the same material. Due to space limitations, the study had to be carried out over a period of several weeks, with an equal number of subjects assigned to the two treatments each week. This process was continued until, under the rules of sequential analysis, enough observations had been obtained to accept or reject the two null hypotheses.

Results

Post-test Data. As mentioned in the design section, in a sequential analysis, after the data from one set of observations have been analyzed, one of three decisions is made: (a) accept the null hypothesis, (b) accept the alternative hypothesis, (c) or obtain more observations. The point at which one arrives at one of these three alternatives will be influenced by the design parameters specified in advanced by the researchers. For this study, we set alpha at .05, beta at .20, and specified an effect size (ES) of three-fourths of a standard deviation, meaning that we were interested in detecting any difference between groups that was larger than 3/4 S.D. (or about 9 items on the post-test). Two groups each containing nine pairs of subjects were tested before the decision was made to stop. Table 1 shows the signed differences between the pairs. In group one, only eight differences are shown because the scores of one pair were tied and no information concerning the relative effectiveness of the two treatments could be obtained from them (see Wilcox on Signed Rank Test, 1945). A negative sign indicates that the score of a flashcard subject was greater than that of his/her paired PSD counterpart.

- - - - - - - - - - - - - - - - -

Insert Table 1 about here

- - - - - - - - - - - - - - - - -

Since the test statistic indicated that the difference between the two groups was not significant at the parameter levels specified, the decision was to accept the null hypothesis and to conclude that there was no significant difference in the performance of the progressive state drill group and the flashcard group on the posttest. Because the effect size of interest (3/4 S.D.) was chosen in advance (the effect size being the minimal amount of effect which would be of practical importance to detect) this result can also be interpreted as indicating that there is no difference that is of practical importance between the two groups.

Attitude Data. Table 2 shows the signed differences between pairs on the attitude measure. This time the test statistic indicated that the difference between the groups was significant and the decision was made to accept the alternative hypothesis and conclude that there was a significant difference in attitude between the progressive state drill group and the flashcard group. The raw data on the attitude measure indicated the difference was in the direction of the progressive state drill group with that group exhibiting a more positive attitude toward the instruction. Again, because the effect size of interest was specified in advance, this result can be interpreted to be a significant difference in statistical terms as well as in practical terms. Means and standard deviations for the progressive state drill group and for the flashcard group are presented in the traditional fashion in Table 3.

- - - - - - - - - - - - - - - -

Insert Table 2 about here

- - - - - - - - - - - - - - - -

Summary and Discussion

The research question explored by this study was whether there would be a significant difference in post-test performance or in attitude toward the instruction between a group of subjects that learned paired-associations using a progressive state drill on a microcomputer and a group which used their own strategy with flashcard. The results of this study show no significant difference in post-test performance between subjects using flashcards and those using the progressive state drill. However, there was a difference in attitude of the two groups toward the instruction with the microcomputer group demonstrating a significantly more positive attitude. Some conclusions and implications for the design of practice drills which can be drawn from the study are given below.

First, it might be concluded that students in this age group have fairly sophisticated strategies for learning from flashcards. The subjects in this study tended to use fairly sophisticated practice and review strategies with the flashcards. For example, most subjects separated the 100 flashcards into separate piles for learning and most reviewed flashcards which they had learned in a fairly systematic manner.

Second, even though the subjects in the flashcard group exhibited a less positive attitude towards the instruction, they learned as many word-number pairs as the subjects in the PSD group. This may add to the body of research which suggests that students do not learn the most from the type of instruction they claim to like the best (Clark, 1982; Clark, 1983).

This study also suggests that designers of computer-based drills more seriously consider the implications of cognitive research on learning verbal information. There is a great deal of literature to suggest that the more meaningful the to be learned material is, the easier it will be learned (Anderson, 1976; Wanner, 1968; Pompi and Lachman, 1967). Because students can remember meaningful information better than meaningless information, instruction should seek to make material as meaningful as possible. This can be done by providing images which relate things together or by emphasizing networks or relationships inherent in the content (Bower, 1970b; Dansereau, 1978; Weinstein, 1978, 1982; Vaughn, 1981) and also through the use of acronyms, mediators, and mnemonics. Other memory techniques such as link and loci (associating material to be learned with spatially organized objects and places) have been shown to help impose some arbitrary meaning on otherwise meaningless material (Bower, 1970a; Bower, 1970c; Gilbert, 1978; Higbee, 1977).

Computer drills which present single items to the learner one at a time are generally intended, not for initial learning, but for practice of material to which the student has already been exposed. Computer drills are generally intended to be used in conjunction with some other means of instruction (computer tutorial, narrative presentation, textbook, etc.) which presents the material initially to the learner. The initial learning of the material should allow the student to utilize some of the techniques mentioned in the previous paragraph. Perhaps flashcards provided the subjects in this study more opportunity to form groups and study relationships among the items, than did the PSD.

The result showing that the subjects using the PSD exhibited a more positive attitude toward the instruction is of practical importance. What this means is that even though students might learn as well using flashcards as they would if they used the PSD on a microcomputer, it is unlikely that they would be motivated to stick with the task. The computer drill is significantly more motivating and engaging. In this study, the flashcard group functioned in a supervised, structured environment and this undoubtedly contributed to the on-task behavior on these subjects.

Finally, some questions can be raised concerning the generalizability results of this study. Since the PSD is designed to be used over a long period of time, it is possible that the design characteristics of the PSD (increasing ratio review, keeping track of working pool from session to session) did not have time to demonstrate their effect during the duration of the experiment. Different results would perhaps be obtained were the subjects to use the PSD for a longer period of time.

It should also be pointed out that the results of this study should not be generalized to different age groups. Younger students undoubtedly would use less sophisticated strategies with flashcards and a comparison between them and the PSD would possibly render very different results.

We would like to add a note of caution. This study should not be viewed as a member of that genre of studies known as "media comparison" studies. The study is not a comparison of microcomputers and flashcards. It does not seek to determine which medium is more effective for learning in general, or for learning paired-associates, specifically. Rather, it is a comparison of one particular drill strategy (the PSD) with students' own flashcard strategies. Different results might be obtained for different strategy comparisons.

Although the results of the study showed "no significant difference" in post-test performance between the two groups, we feel that this study provides a valuable contribution to the literature on computer-based instruction in that it is one of the experimental studies in this area in which the researchers specified in advance the alpha level (of Type 1 error), the effect size of interest, and the statistical power (1-beta) desired to detect a difference if it did exist. Only when these levels are specified in advance can a sample size be assured that is adequate to detect a difference between the groups.

Also, the methodology known as sequential analysis is a valuable alternative methodology for researchers in the area of computer-based instruction. Sequential analysis allows the researcher to avoid having to predetermine the sample size. In most cases, a decision can be reached with fewer observations than would be possible with other types of research designs. Sequential analysis also requires the investigator to make certain decisions prior to conducting the experiment regarding the conditions under which the null hypothesis can reasonably be regarded as true. Recent secondary analyses of the statistical power of research studies in the behavioral sciences (Daly & Hexamer, 1983) indicate that in the great majority of studies power is quite low, (i.e. type two error rates are large). When using sequential analysis, the researcher is required to consider power *a priori* thus assuring that the sample size is large enough to detect a difference between the groups.

Computer drill and practice programs are widely viewed as potential instructional tools for teaching. More studies should be done to compare various computer-based drill and practice paradigms with one another and with non-computer-based strategies.

Author Note

The specific sequential analytic technique used in this study was the Sequential One-Sample (Paired Samples) Configural Signed Rank Test (CSRT) originated by Weed and Bradley (1971). The design parameters required by this test are alpha, beta, and the effect size (ES) one wishes to be able to detect. For this experiment, these parameters were set as follows: alpha = .05, beta = .20, ES = three-fourths of a standard deviation. In this test the differences between the scores of the matched pairs in each group are compared and rank ordered in terms of their absolute magnitudes. The probability of the particular configuration of signed ranks is computed under a hypothesis of no difference, H_0, and also under an alternate hypothesis, H_1, in which a difference in favor of one group of 3/4 S.D. or more is postulated. Data are then collected until the researcher reaches the point at which H_0 or H_1 can be accepted. In the current study, a two-tailed version of the CSRT was desired so the probability ratio was modified to test the alternative hypothesis that the ES was ± 3/4 S.D.

The authors would like to thank F. J. King, Ken Brewer, and David Paulsen for their help with the design of this study and in the use of sequential analysis and Patricia Tolbert and Diane Fryman for their assistance in running the study.

References

Alessi, S. M., & Trollip, S. R. (1985). Computer-based instruction: Methods and development. Englewood Cliffs, NJ: Prentice-Hall.

Anderson, J. R. (1976). Language, memory, and thought. Hillsdale, NJ: Erlbaum.

Anderson, J. R. (1980). Cognitive psychology and its implications. San Francisco: Freeman.

Atkinson, R. C. (1974, March). Teaching children to reach using a computer. American Psychologist, 169-178.

Bower, G. H. (1970a). Analysis of a mneumonic device. American Scientist, 58, 496-510.

Bower, G. H. (1970b). Imagery as a relational organizer in associative learning. Journal of Verbal Learning and Verbal Behavior, 9, 529-533.

Bower, G. H. (1970c). Organizational factors in memory. Cognitive Psychology, 1, 18-46.

Clark, R. E. (1982). Antagonism between achievement and enjoyment in ATI studies. The Educational Psychologist, 17(2), 92-101.

Clark, R. E. (1983). Reconsidering research on learning from media. Review of Educational Research, 53, 445-459.

Daly, J.A., & Hexamer, A. (1983). Statistical power in research in English education. Research in the Teaching of English, 17, 157-164.

Dansereau, D. (1978). The development of a learning strategies curriculum. In H. F. O'Neil, Jr. (Ed.), Learning strategies (pp. 1-29). New York: Academic Press.

Educational Testing Service. (1963, June). Kit of Reference Tests for Cognitive Factors, Test for Factor Ma: Associative Memory, Object Number Test--Ma-2 (Project NR 151-174). Princeton, NJ: Author.

Gilbert, T. F. (1978). Human competence. New York: McGraw-Hill.

Higbee. K. (1977). Your memory: How it works and how to improve it. Englewood Cliffs: Prentice Hall.

King, F. J., and Roblyer, M. D. (1984). Alternative designs for evaluating computer-based instruction. Journal of Instructional Development, 7(3), 23-29.

Merrill, P. F., & Salisbury, D. F. (1984). Research on drill and practice strategies. Journal of Computer-Based Instruction, 11(1), 19-21.

Pompi, K. F., & Lachman, R. (1967). Surrogate processes in short-term retention of connected discourse. Journal of Experimental Psychology, 75, 143-150.

Salisbury, D. F. (in press). Effective drill and practice strategies. In D. H. Jonassen (Ed.), Instructional designs for microcomputer courseware. Hillsdale, NJ: Erlbaum.

Salisbury, D. F. (1984, April). Cognitive psychology and its implications for designing drill and practice programs for computers. Paper presented at the annual meeting of the American Educational Research Association, New Orleans, LA.

Salisbury, D. F., Richards, B. K., & Klein, J. D. (1985). Designing practice: A review of prescriptions and recommendations from instructional design theories. Journal of Instructional Development, 8(4), 9-19.

Seigal, M. A., & Misselt, A. L. (1984). An adaptive feedback and review paradigm for computer-based drills. Journal of Educational Psychology, 76(2), 310-317.

Vaughn, E. (1981). Cognitive strategies: A review of some recent literature. (Contract No: DABT60-81-C-006). U.S. Army Training Support Center.

Wanner, H. E. (1968). On remembering, forgetting, and understanding sentences: A study of the deep structure hypothesis. Unpublished doctoral dissertation, Harvard University.

Weed, H. D. & Bradley, R. A. (1971). Sequential one-sample grouped signed rank tests for symmetry: Basic procedures. Journal of American Statistical Association, 66 (334), 321-326.

Weinstein, C. (1978). Elaboration skills as a learning strategy. In H. F. O'Neil, Jr. (Ed.), Learning strategies (pp. 31-55). New York: Academic Press.

Weinstein, C. (1982). Learning strategies: The metacurriculum in community college teaching. Unpublished manuscript, The University of Texas at Austin.

Table 1

Signed Achievement Differences Between Pairs of Students in the Two Groups: Posttest

Rank Ordered Differences Between Pairs		Configuration of Signed Ranks	
Group 1	Group 2	Group 1	Group 2
-21	34	-X	X
-18	28	-X	X
-13	-17	-X	-X
9	-16	X	-X
-7	16	-X	X
-6	-8	-X	-X
-5	-8	-X	-X
3	5	X	X
	-3		-X

Note 1: A negative sign indicates that the score of the flashcard subject in that pair was greater than his/her PSD counterpart. In group one, only eight differences are shown because the scores of one pair were tied and no information concerning the relative effectiveness of the two treatments could be derived from them.

Note 2: The rejection region for the test statistics is based on alpha =.05, B = .20, and ES = 3/4 S.D.

Table 2

Signed Differences Between Pairs of Students in the Two Groups: Attitude Measure

Rank Ordered Differences Between Pairs		Configuration of Signed Ranks	
Group 1	Group 2	Group 1	Group 2
45	39	X	X
44	37	X	X
30	24	X	X
29	-22	X	-X
24	19	X	X
12	-15	X	-X
-11	-14	-X	-X
9	7	X	X
5	5	X	X

Note 1: A negative sign indicates that the score of the flashcard subject in that pair was greater than his/her counterpart.

Note 2: The rejection region for the test statistics is based on alpha =.05, B = .20, and ES = 3/4 S.D.

Table 3

Means and Standard Deviations for the PSD Group and the Flashcard Group

	Posttest		Attitude	
	PSD	Flashcards	PSD	Flashcards
Mean	21.9	22.8	74.3	57.9
S.D.	11.8	14.8	9.6	16.9

TEACHERS' OPINIONS AND ATTITUDES ABOUT INSTRUCTIONAL COMPUTING: IMPLICATIONS FOR STUDENT EQUITY

By
Nancy N. Knupfer
Wisconsin of Wisconsin - Madison

Mailing Address:
207 Bacon Street
Waunakee, WI 53597

Paper presented at the Annual Conference of the
Association of Educational Communications and Technology

Atlanta, Georgia
February, 1987

ABSTRACT

The purpose of this study was to assess the equity of student access to instructional computing at the sixth grade level in Wisconsin public schools in the Spring of 1985. This goal was accomplished by examining the status of instructional computing and the teachers' perceptions, opinions and attitudes about instructional computing practices during 1984-85 school year.

The data were gathered by means of a mailed questionnaire that contained both closed- and open-ended questions. Five hundred ten questionnaires were mailed to all sixth grade teachers in all K-6 structured public schools throughout the state of Wisconsin. Follow-up telephone interviews with nonrespondents obtained data for comparison of respondent and nonrespondent groups.

This paper reports some of the study's significant findings both about the nature of teachers' attitudes and opinions about instructional computing, and the potential effect of these viewpoints on the students' access to computers. The exploratory nature of this study determined the types of statistical methods that were used to analyze the data. Descriptive statistics reported in this paper were compiled from frequency distributions, measures of central tendency, contingency tables using the chi-square statistic, and t tests. The alpha level for significance was set at .05.

The major conclusion of the paper was that equity of student access to instructional computing is closely related to the attitude and opinions of the teachers who work with those students.

TEACHERS' OPINIONS AND ATTITUDES ABOUT INSTRUCTIONAL COMPUTING: IMPLICATIONS FOR STUDENT EQUITY

INTRODUCTION

Although microcomputers make computer technology increasingly available for both home and school use, our knowledge of the educational impact or potential of computers in our schools lags far behind the awakened public concern with "computer literacy" and "education for the future." Recent research indicates that despite the great potential offered by microcomputer technology, the scarcity of firm evidence on its educational strengths and weaknesses cautions us about the new technology's potential educational impact (Sheingold, Kane, Endreweit, & Billings, 1981, p. 4).

The quantitative growth in this field has been enormous, as the demands of parents, industry, and the students themselves have caused schools to purchase ever larger numbers of microcomputers (Marrapodi, 1984). This rapid acquisition of new equipment has not necessarily improved education, however. Indeed, the novelty of the computer stands in immediate contrast to the traditional attitudes, the teaching methods, and the rigid bureaucracy that had survived the initial computer invasion of the 1960s (Oettinger, 1969, in Sheingold et al., 1981). Furthermore, this immense growth in educational computing has been accompanied by inequitable practices both in the curricula and in the access of the students to the machines.

Educational equity is a complex subject, but basically it means simple *justice* -- that all persons be afforded an "equal chance" for a good education. Justice requires treating people identically in ways in which they are equal and differently when they are unequal in some *relevant* way (Bennison, Wilkinson, Fennema, Masemann, & Peterson, 1984). It is sometimes difficult to distinguish between the two, but "inequality" does not necessarily entail "inequity." Inequalities may occur due to choice, ability, or tenacity in achieving a goal, but inequities imply unfairness (Green, 1983). One is descriptive, the other prescriptive. Fairness within the educational system sometimes calls for equal opportunities, while other times different opportunities provide equity. People are equally entitled to equitable treatment.

Several studies show that inequity exists in American computer education, (Anderson, Welch & Harris, 1984; Becker, 1982, 1985, 1986b; Schubert & Bakke, 1984; Sheingold et al., 1981), and that problems frequently arise from the moment computer literacy enters the curriculum (Lacina, 1984; Enochs, 1984). Edwards (1984) in particular distinguishes between quantitative and qualitative inequities. Quantitative inequity results from shortages of money and equipment. Qualitative inequity involves intangible attitudes and institutional biases that presumably pose a greater long-term threat to equal access and use.

But the distinction is in many ways less important when qualitative and quantitative factors combine to create inequities that cannot be eradicated by addressing one type of cause alone. Both of them lead to inequitable decision-making: the school or the teacher responds by limiting access according to unfair priorities. For example, a shortage of computers might reinforce a teacher's current disposition to target the teacher's favored group. So even though the computer is intrinsically non-discriminatory, schools often use it selectively, scheduling access to the advantage of certain populations, (boys, affluent, or gifted students), over others, (remedial, minority, or disadvantaged students) (Schubert & Bakke, 1984; Becker, 1984, 1985, 1986b). More important, though, is the fact that inequities, no matter how distant, varying, or indeterminate their source, converge in the classroom and are closely related to the way teachers think about and use computers.

As the most salient research confirms, the teachers' particular preconceptions are crucial to the course of innovation and change. Any change or innovation in education must be meaningful to the regular classroom teacher -- that is, it must fit into the current classroom world and still cultivate the teacher's sense of educational adventure -- before any innovation can be successfully implemented. Even though many educational innovations are adopted by the most far-sighted, enlightened school administrations, they are doomed if the classroom teacher won't accept them (Cuban, 1986; Fullan, 1982; Weinshank, Trumbull & Daly, 1983).

Cuban notes the importance of both constancy and change when implementing new innovations within the schools (1986). According to Cuban, teachers work within a realm of embedded policies and work routines which must adjust to any proposed change. He points out the positive aspects of stability and craft within instruction, and notes that because "teachers are the gatekeepers for instructional technology" (p. 37), they must be consulted and involved in the introduction of any new innovation, including educational computing. Further, the importance of *how* an innovaton is implemented is much more important than *what* is implemented (Berman & McLaughlin, 1976). It is plain, then, that the more closely computers are attuned to the existing rhythms of school life, the better the chance of meaningful computer use for all students (Cuban, 1986; Fullan, 1982). Until teachers accept the computer as a valuable part of the school curriculum and have enough of them to use, computer education will not live up to its full potential in the public schools.

Unfortunately, this simple fact has been lost in the rush to assess the impact of educational computing in the schools. As Cuban reports, most studies about the classroom assimilation of technology have limited their audience and their subject to educational reformers and administrators, rather than to teachers (1986). He points out that an effort must be made "to correct an unhealthy imbalance in most writing about classroom reform, which ignores the teacher's perspective" (p. 7). Outsiders often misunderstand educational change. As several researchers have noted, we need a more accurate study of educational change and implementation of innovations that is based on life *within* the schools (Berman, 1981; Berman & McLaughlin, 1978; Sarason, 1982). Thus, any change in teaching practice requires the investigation and assessment of the teacher's viewpoint at the succeeding stages of planning and implementation, as well as a clear definition of what is to be implemented. "Who implements?" is just as important a question as "what are we implementing?"

One stumbling block to answering these basic questions is the unfocused quality of educational computing's objectives. If computer literacy is the goal, then the ongoing debate about its definition needs to arrive at a practical consensus that teachers can grasp. For if they do not understand it, then their efforts to teach it will be diffuse, frustrating, and eventually harmful to the program and to the students. Moreover, because the teacher's selection of a type of instructional use can promote or retard the learner's heuristic, cognitive development, uninformed decisions can deprive students of equitable, effective access to the machines. Equitable access, equal opportunity, and a clear understanding of objectives all go together (Alvarado, 1984; Anderson et al., 1984; Becker, 1986b, 1982; Edwards, 1984; Lesgold & Reif, 1983; Sheingold et al., 1981).

Any diagnosis of the inequities in current educational computing reads like a catalog of our present social ills. So it is important to caution that the desirability of equal access must be tempered by a wise concern for diversity in education. If the microcomputer's strength is its adaptibility and capability for individualized instruction, and if mutual adaptation to local needs is characteristic of computer implementation, then it is possible that this admittedly neutral piece of equipment can reinforce our existing prejudices while it encourages individual initiative and higher-order thinking.

While we debate these difficult questions, the schools continue to struggle with implementing this innovation. And our wildest dreams about ideal computer use in the schools may easily be dashed by the most basic attitudes and behaviors that, for whatever reasons, differentiate humans from each other. Thus any successful implementation of computer education must plan for these existing inequities, try to ameliorate their excesses, and attempt to bring the value of computer literacy to as wide a constituency as possible.

PURPOSE

The purpose of this study was to assess the equity of student access to instructional computing at the sixth grade level in Wisconsin public schools in the Spring of 1985. This goal was accomplished by examining the status of instructional computing at the sixth grade level and the perceptions, opinions and attitudes of the teachers who worked with sixth grade students during the school year under study. The study examined several variables related to the implementation of microcomputers in Wisconsin elementary schools, including teachers' opinions and the extent of teachers' training, student:computer ratio, geographic region, the influence of district wealth, and school planning for instructional computing. This paper does not summarize the entire study. It reports findings about certain aspects of student access to computers, and about teachers' opinions and attitudes toward instructional computing which may affect equity of student access.

METHODOLOGY

The data for this study were gathered through a survey instrument mailed to all full-time sixth grade teachers in all K-6 structured public schools in Wisconsin, and then were analyzed through appropriate statistical techniques. The first and second mailings of the survey instrument garnered 55% and 17% respectively, for a total of 72% of the 510 teachers in the sample; 369 respondents. Follow-up telephone interviews with non-respondents helped to control for variations between respondent and non-respondent groups. T-tests and chi-squares on several variables revealed no significant differences between the two groups.

The questionnaire and research design incorporated two levels of measurement: district or school data, (financial conditions, the existence of current instructional computing curricula, geographic region, basic demographic data), and individual teacher data, (measures of attitudes and opinions about various aspects of instructional computing at the school, the extent of training and preparation for educational computing, and descriptive data about availability of machines). Financial conditions and certain demographic data were obtained from the Wisconsin Department of Public Instruction (DPI). A copy of the questionnaire is appended to this paper.

Because this survey sampled all sixth grade teachers in the selected schools, irrespective of their current or past contact with computers, each sampled school contained between one and three teacher respondents. Due to that characteristic of the sample, and because the teacher was of primary interest of this survey, the teacher was the unit of analysis for all questions except those specifically concerned with school level data. The analyses of school data included each school only one time, regardless of the number of teacher respondents representing the school.

The survey instrument specifically asked how teachers were implementing computers, considering the influence of both the number of machines and time pressures natural to the school day. Focused questions were used to discern and elaborate teacher perceptions, opinions, and attitudes about issues surrounding instructional computing and to learn about patterns of microcomputer usage, the composition of groups receiving instruction, the various instructional applications of computing, and the equity of access among students. The survey suffers from weaknesses common to all such polling techniques; the teachers' answers were subjective and limited both by the requirement that they quantify their views and by their unique position in the school hierarchy.

Statistical analysis of the resulting data provided valuable insights into teachers' opinions and attitudes, and the relationship between equity and implementation practices, while offering promising suggestions for future research. All findings of significance were at the .05 level, unless otherwise noted.

RESULTS AND DISCUSSION

INEQUITIES IN WISCONSIN'S EDUCATIONAL COMPUTING

Material Inequities

Do all schools have computers? If so, are those computers distributed in the same ratio among schools?

All of the school districts respresented had at least one computer and the large majority of schools within those districts had their own computers. Only 17 of the 369 teacher respondents reported no access to computers at all. Those 17 teachers represented 14 schools which were spread throughout several districts, CESA regions and counties. This distribution indicates that although all school districts had computers, the distribution of computing resources within districts varied.

Of the 238 schools with computers, 55% had five or fewer computers and 85% percent had between 1 and 10 machines; only 15% had more than 10 machines. The median number of computers per school (5) and the ratio of students per computer (58:1) were lower in Wisconsin than in the nationwide sample (6 and 60:1), reported by Henry Becker, of Johns Hopkins, in a study conducted during the same semester as the study reported here (1986a). Although schools with higher enrollments had a larger number of computers, an analysis of variance showed that the increase in number of school computers was not proportionate to the increase in enrollment, suggesting that school microcomputer purchases were not based upon the enrollment, but on other factors.

Do students receive enough instruction and practice time to become competent computer users?

Seventy-nine percent of the teachers stated that their schools needed more computers, and 77% believed that students did not receive enough instruction and practice time to become competent computer users. Over half of the teachers believed that the main reasons for lack of instruction and practice time were not enough access to computers and time constraints of the regular curriculum (see Table 1). Insufficiency of resources was reported by Becker (1982) as the major complaint during the early phase of microcomputer implementation. The emphasis on curricular time constraints reported in this study indicates that schools need more than additional numbers of computers. Instructional programs need to be developed which use the computers to promote student learning of instructional goals, not goals of a specific computer program.

[Insert Table 1 about here.]

Perhaps the shortage of computers promotes the attitude that an important resource should be rationed or that its future in the school is uncertain and therefore that important elements of the curriculum should not depend upon its limited availability. The structure of the elementary classroom and typical teaching practices generally lend themselves to group instruction and common activities among larger groups of students. A creative teacher can certainly find ways to promote individual or small group activities, but that does take more planning, preparation and follow through; something the average teacher may not be able to do given the demands that already exist in the job.

Spacial Inequities

Several factors -- location, length of time computers could be kept, how often classroom computers were used, and how many hours they were actually turned on during a day of use -- highlighted inequity of access to computers among sixth grade students. The large differences in the total time each student had access to a computer in the classroom depended upon the total amount of time allocated for specific classrooms to share the computing resource; classroom access ranged from zero days to the entire school year. Furthermore, different patterns of computer access reported by teachers indicated that students' access to computers might very well depend on the enthusiasm of the particular classroom teacher.

Of the 352 teachers with computers in their schools, about 80% claimed that fewer than half of the students used computers on a regular, weekly basis. The major reasons teachers gave for "less than weekly use" were divided among problems concerning remote location of computers, time constraints of the main curriculum, and lack of teacher training. Following in order of importance were lack of computers, funding restrictions to specific student groups, lack of necessary software, undeveloped program, funding limitations to specific curricular areas, and lack of student interest (see Table 2).

[Insert Table 2 about here.]

Curricular Inequities

Fifty-seven percent of the schools did not require any instructional computing for students; in fact, five percent of the schools did not have computers. This study showed that 43% of the schools required instructional computing for students, but it cannot be assumed that those requirements were based on equivalent skill levels or equal amounts of time at the computer.

Which students were most likely to use a computer?

Two hundred thirty-two teachers (62%) had computers in their classrooms at some point during the school year; six of them (2%) did not supervise computer use themselves, but gave the responsibility to another adult. Sixty-four (27%) of those teachers with classroom computers indicated that only certain students within their classrooms used a computer at some time during the school year. Those teachers were asked, via an open-ended question, to identify which students were most likely to use a machine. According to Table 3, the students most likely to use a computer were those who had their regular work finished, were interested, competent, above average achievers, or had a computer at home.

[Insert Table 3 about here.]

Clearly, teachers who required that regular classroom work be complete prior to using a computer imposed a restriction on use which treated computers as an "extra" in relation to the regular curriculum. Witholding the computer until regular schoolwork was finished supports Cuban's (1986) finding that instructional media, including the computer, are often viewed as an "extra." If computers were used to support the regular curriculum, all students would have a need to use a computer to complete a project and teachers could hardly require that all work be finished prior to using the tool intended to help complete that work.

The requirement that students be competent prior to using a computer also deserves comment. Students who are novices may not be able to get the help they need to use a machine, thus those who are experienced may gain more experience while those who are inexperienced are prevented from gaining the experience. The various instructional uses of computers can, if improperly implemented, divide communities and groups by creating "haves," who are equipped with an effective survival skill, and computer-illiterate "have nots," who are ill-equipped to cope wih the age of computer information systems (Anderson et al.,1984).

In spite of reports in the literature that more aggressive students get to the machines first (Fisher, 1984; Schubert and Bakke, 1984), this study indicated only one response of that nature. However, it is possible that aggressiveness is inherent within other statements.

What general quality of computer use regarding high- and low-level thinking skills do teachers report; are equivalent skill levels of computer use reported for student groups of gifted, average, and remedial learners?

If low-level thinking skill uses encourage rote memorization under the control of the program, and high-level uses promote independent thinking and stimulate curiosity, then the degree of the learner's exposure to these techniques can either stunt or improve computer literacy in terms of cognitive development. The teachers summarized their perceptions about the general quality of computer use regarding high- and low-level thinking skills for each of three student groups of gifted, average and remedial learners by filling in a matrix with the percentage of usage along these categories. It is possible that many of them did not know precisely what the percentage of usage was for certain groups of students not under their direction; some of them had difficulty filling in the matrix. The results, nonetheless, are quite interesting. They were tabulated, categorized, refined, and through a process of elimination, further tested in order to measure the quality of students' learning activities with the computer. A glance at Table 4, which displays the mean percentages of all categories, reveals that the mean percentages of use reported for spreadsheets, data bases, telecommunications, robotics, and other were quite lower than in the remaining categories in the matrix. Therefore, those five categories were not used for the analysis in this section.

The games category had the highest mean percentage among the types of computer activities reported for gifted students, followed by drill and practice, and then writing programs.

Average and remedial students used computers in two predominant ways; mostly drill and practice, followed by games. Many computer games are nothing more than drill and practice, while others are sophisticated simulations requiring a good deal of strategic thought. Even though the games category appeared to be substantial for all three student groups, games were excluded from the analysis here because the crudeness of measurement did not allow refinements to assure that the thinking skill level was equivalent for all types of games reported. A two-way analysis of variance showed that in general, teachers reported the most usage for average students, followed by gifted, then remedial students (see Table 4).

[Insert Table 4 about here.]

After elimination of the above mentioned categories, the remaining categories were combined into related high- and low-level thinking skill groups. The high-level skill group, then, included writing programs, word processing, and simulations, while the low-level skill group covered tutorials, drill and practice, and demonstrations. Table 5 shows a breakdown of the high- and low-level skill activities for the general sixth grade student population. According to teachers' reports, students received about four times (24%) as much drill and practice as any of the high-level skills. The drill and practice category also had the most variation among the six activity types included here. The minimum of zero for all groups indicated that at least one teacher reported no use at all for each category. Ratings of 100% in the categories of write programs, and drill and practice, indicated that all sixth grade students in certain schools were engaged solely in writing programs or in using drill and practice software. Also, the mean total of low-level usage was nearly twice the mean total for high-level usage.

[Insert table 5 about here.]

In a further refinement of this data, the total high- and low-level activities were separated into the three student groups of gifted, average, and remedial learners. It became obvious that gifted students were engaged in more high-level activities, while average and remedial learners were engaged in more low-level activities. This is apparent in Table 6, which shows the mean of high- and low-level usage for each of the three student groups. Results of Wilcoxon matched-pairs signed-ranks tests on high- and low-level use between the student groups confirm these differences as significant (see Tables 7 & 8). High-level use was greatest for gifted students, followed by average students and least for remedial students. Low-level use was greatest for average students, followed by remedial students and least for gifted students. This finding is consistent with earlier reports about qualitative inequity in instructional computing (Alvarado, 1984; Anderson et al., 1984; Becker, 1984; Sheingold et al., 1981).

[Insert Tables 6, 7 & 8 about here.]

TEACHERS' ATTITUDES

The Benefits of Computing

The teachers' attitudes and opinions about the value of educational computing in their schools varied widely and reflected a general confusion about the purposes of the program. All teachers, regardless of whether their schools had computers, were asked their opinions about the best aspects of instructional computing via an open-ended question. Responses to the question were categorized and are shown in Table 9. Although many teachers believed that the program had some value, they were divided on what that value was and how it should be related to the purposes of educational computing. Clearly, student motivation was the predominant factor that teachers believed was most valuable -- one hundred seventeen teachers listed "motivation" as their top choice.

Teachers commented that instructional computing added interest, posed a challenge, could be used as a reward, and offered a change of pace in the school day. It may be true that students tend to be highly motivated by computer use, but one must then wonder about the depth, quality, and educational consequences of that motivation. Are students stimulated by the computer's novelty? If that is the case, then how long will the motivation last after students get used to the machines? Here again, the need for teacher training and a solid plan for implementation needs to be emphasized so that students are challenged with new experiences with instructional computing as they progress through the grade levels. Apparently there is a striking preoccupation with the immediate classroom environment and not much understanding about the larger purposes of educational computing. After all, "motivation" could justify any number of questionable innovations in the school.

This preoccupation with keeping students interested and motivated is a natural concern of the modern teacher. And certainly it does not indicate a myopic view of computers, either. In fact, a number of teachers believed that the program's value was in its preparation of the students for survival in the computer age, and for life in general. Interestingly, only a small number actually pointed to either the higher-order thinking skills or the particular abilities that computers supposedly cultivate.

[Insert Table 9 about here.]

The second most frequent response in Table 9 (nearly 20%) is the need to prepare students for life in the future. Teacher comments here reflected the need to keep up with the changes in technology and society by at least creating or maintaining student awareness of these issues.

Despite strong claims that instructional computing helps or increases learning, only 11% of the teachers specifically indicated that as a benefit. This category was viewed separately from the category of logic, which drew about five percent of the responses. The logic category included specific reference to problem solving or critical thinking skills. Although these logic skills may be thought to increase learning, the researcher kept the categories separate on the basis of the tone or wording of the teachers' responses. Clearly different emphases were being made.

Ten percent of the responses comprised the fourth largest category in Table 9, that of job preparation. Teachers claimed that students need to be prepared for the job market of the future and that instructional computing offers skills in typing and word processing, as well as unspecified job and life skills. If job skills are to be the goal of instructional computing, then more emphasis needs to be placed on both defining the skills needed to achieve that goal and providing an opportunity for all students to be exposed to quality computer education. Schools can hardly justify preparing some students better than others for the job market.

Twenty teachers claimed that there was absolutely nothing good about instructional computing. Those who indicated "variety" specifically referred to *potential* versatility of software. They did not necessarily like the software currently available. See Table 9 for details about other opinions expressed regarding the best aspects of instructional computing.

Who Ought to Have Access?

Confusion of attitudes and opinions about the goals, value, and general validity of educational computing were particularly clear when the teachers were asked what their preferred criteria for access to computers would be, given a hypothetical shortage of machines that would force them to ration usage. This question was directed to all teachers, regardless of whether or not their schools currently had computers. (Several teachers commented that their schools did have a shortage of computers so the question seemed more realistic than hypothetical; and considering that shortages of machines ranked high among teachers' complaints about actual conditions, the responses to this question were suggestive of the kinds of decisions about access actually made in these schools.) Although the largest number ranked "equal access" as their highest standard, this criterion co-existed with views that hardly promote equal access, even in a rationing situation.

The main response categories that the teachers wrote in are listed in Table 10. Equal (their term) access was the most predominant of any single consideration, comprising nearly 37%, of the 252 teachers who responded to this question. Although 75% of the 369 teachers sampled believed that schools had acquired microcomputers before teachers were trained to use them, the second most preferred criterion for determining access was the ability of the students' teacher. This criterion clearly would prevent some students from having access to a computer at all, especially those whose teacher believed that computers had no place in the schools. In Wisconsin, most schools do have computers and some teachers are eagerly using them, so teachers who defer to more competent colleagues in the determination of access to the machines are also depriving their students, regardless of their educational needs, of access to the computing resource. Because elementary schools tend to be more self-contained in structure than the older grades, this criterion of teachers' competency might have a more serious implication for sixth grade students than for junior high or high school students who are exposed to more variety of teachers.

[Insert Table 10 about here.]

Two other categories mentioned by about 25% of the teachers stressed the motivational or remedial purposes of computing. "Motivation" meant that the computer should be used as a lever to encourage good behavior. Better-behaved students would have a better chance of getting to the machine. Does this mean that students with behavior problems (or personality conflicts with their teachers) do not deserve the same chance to develop skill at using computers? This access criterion conflicts with the others teachers listed, because poorly-behaved students will not have an adequate chance to reap the benefits, (develop higher-order thinking skills, or prepare for the job market, or obtain necessary life skills), that teachers claimed. This type of restriction underscores the fact that the goals of instructional computing are unclear and that computers are not viewed as a regular part of the standard curriculum which is accessible to all students at some level. Behavior modification is not one of the objectives normally associated with computer literacy, any more than it is an accepted goal of the math, science, or language curricula.

The category of remedial reinforcement was explained as basic drill and practice for students who needed to develop their academic abilities. Even though giving priority to remedial students might seem to favor some students over others, it is important to remember that all students do not have the same needs. The danger inherent in remedial usage is more likely to lie in the steady diet of drill and practice programs, which do little to harness the student's interest in the computer to the development of higher-order thinking skills.

General Problems

All teachers were asked to state their beliefs about the worst problems, in general, with instructional computing. This, like the preceding question was open-ended; responses were categorized and results are reported in Table 11.

[Insert Table 11 about here.]

The teachers' major complaints about instructional computing focused on material, managerial, and training problems. Heading the list, claimed by about 36% of the 293 respondents, was the shortage of computers and/or software. Within this category, some teachers mentioned that lack of space in which to put the equipment prevented an increase in inventory. Similar comments referred to the unjustifiable expense of computer education relative to other important curricular priorities, and to the poor quality of software (10.9% each). Teachers were concerned that commercially available software did not match their curriculum's requirements for skill level and content.

Major managerial concerns included time constraints of the daily curriculum (25.3%) and time limitations in teachers' schedules (9.6%). If combined, these two categories might represent a larger category of general time concerns, becoming the most predominant single problem; even greater than lack of program direction or teacher training. Time limitations in the teachers' schedules reflected the need to properly plan for use of instructional computing, both in reviewing software and planning for implementation into the existing curriculum for both long range and immediate use. The importance of repeated statements about time concerns throughout the questionnaire cannot by overstated, especially in consideration of Maftoon's claim that time constraints are one of the four main reasons for failure of innovations to be implemented (1982, in Cuban, 1986.)

About 20% of the responses blamed inadequate teacher training for the problems of instructional computing. Another 17.7% faulted the lack of program direction. In fact, the teachers reported a dismal median of three hours of inservice training as their only directed experience with computers. These figures, reinforced by the frequent appearance of similar complaints throughout the questionnaire, put into sharp focus the limited and often confused quality of the teachers' understanding of the objectives of educational computing.

These material and managerial complaints could be resolved within the context of a plan to redress shortages and provide training, but a significant number of responses to this question revealed an underlying unease with computer education in general, regardless of material or managerial factors. A number of teachers indicated that many teachers question the value of educational computing, are aware that their fellow teachers don't care about or are afraid of the program, and believe that the program's touted objectives are unrealistic. Questionable educational value was mentioned by both those who had and had not used instructional computing. Certainly teachers need to believe that there is educational value to any proposed innovation if they are to implement it in their classrooms (Cuban, 1986; Fullan, 1982; Lortie, 1975; Miles, 1980). Until teachers are convinced of the value of instructional computing, they will make no more than a half-hearted attempt to use it. Fear of change is an obstacle that cannot be successfully overcome until the those responsible for making the change understand and appreciate its value (Cuban, 1986; Fullan, 1982; Kanter, 1983).

In a different part of the questionnaire, teachers with computers in their schools had been asked what major problems had been experienced with instructional computing in their schools. As indicated in Table 12, lack of time, computers, and teacher training lead the list. This is consistent with the top three problems reported in Table 11. Lack of program objectives and poor quality software also were indicated consistently. The emphasis on such management issues as supervision and grading procedures, suggests the extent to which teachers who use computers are still struggling to fit them into their normal routines. This is another area worth noting since ease of implementation into the regular classroom routine is a major factor in the success of educational innovations (Berman and McLaughlin, 1978; Cuban, 1986; Fullan, 1982; Lortie, 1975; Miles, 1980; Sarason, 1982).

[Insert Table 12 about here.]

Differences Among Teachers: The Split Between Users and Nonusers.

Approximately one third of the teachers responding to this survey did not use computers at school. Table 13 documents the nonusers' reasons for their decision to avoid computer education. Four-fifths of the responses claimed that remote location of the computers caused difficulties with scheduling access to the machines or supervising the students. Seventy-six responses cited a shortage of equipment, while large percentages pointed to the management difficulties arising from these material and spatial factors. Finally, 64.3% of the responses blamed the absence of training that would overcome their apprehensions about computing.

[Insert Table 13 about here.]

In sum, when asked to explain why, unlike some of their colleagues, they had decided against using computers, these "nonusers" raised the same complaints common among the users of machines. Indeed, the most interesting thing about these two groups is that they reacted differently to common problems. Nonusers responded by avoiding computers. But users, who brought up the same complaints, still tried to keep computers in the classroom. One group refuses to change because the machines present too much of a challenge to their current attitudes, practices, and environment. The other group is trying to change, but finds the going rough.

It is not surprising, then, to find that users and nonusers have different attitudes about the utility, validity, and general worth of computers in the schools. Chi-square tests were performed on the categories of access criteria, best aspects, worst aspects, and major problems by sex, age, and use/nonuse of computers revealed these important differences. Significant relationships at alpha .05 or less are shown in Table 14.

[Insert Table 14 about here.]

Several questions were intended to measure positive attitude, negative attitude, discriminatory attitude, and attitude about the teacher's own competence to use computers for instruction. Questions intended to measure these attitudes were based upon a Likert-type unipolar scale of 1-5 with values as follows: 1 = Strongly Agree, 2 = Agree, 3 = Undecided, 4 = Disagree, and 5 = Strongly Disagree. Questions were grouped according to the type of attitude; values for each group were then summed, creating interval scale measurements.

Positive attitudes were measured by the degree to which teachers agreed that computers were a welcome addition to school curricula, a necessary investment for schools, enhanced the quality of education, were helpful in teaching language arts, and the degree to which teachers felt more computers would promote access for more students. Language arts certainly is not the only subject area application of computers, but is one indication of assimilation into the existing curriulum.

Negative attitudes were based upon teachers' reactions to statements that computers complicated the teacher's job, diverted attention from basic curricula, computers were a passing fad, money spent on computing would be better spent on other materials, and that computers should be reserved for the high school level instead of the elementary grades.

Discriminatory attitudes would be revealed by reactions to statements that computers were more appealing or necessary for boys than for girls, prediction that handicapped students would not succeed with computers, and priority for computer use should be given to specific student groups.

Teachers' attitudes about their own competence to use computers for instruction were also important. Questions about competency addressed the ability to teach with some kind of computer software, to understand the operational logic of computers, to teach programming, and to use telecommunications or robotics in the classroom.

T tests on positive attitude, negative attitude, discriminatory attitude, and attitude about competency, by sex of the teachers, showed no significant differences for any of the four variables. But as Table 15 shows, T tests on the four attitudinal categories between teachers who had used and had not used computers during the school year, showed a significant difference in all areas. The lower group means indicated that those teachers who used computers had more positive attitudes toward instructional computing and stronger feelings of competence. Those teachers who had not used computers had more negative and discriminatory attitudes toward instructional computing. The point here is not that the schools are divided among those who like computers and those who don't like them, but between those who are willing to use them and those who are not. Nonusers are not convinced that computer education is worth the effort to adjust their current practices; users are making the effort, but with difficulty.

[Insert Table 15 about here.]

Teachers' age was divided into two groups; those age 40 or younger, and those age 41 or older. The age grouping was selected based upon the mean age of 42 for the total sample group of teachers. Results of the T tests in Table 15 also indicate a significant difference in positive and negative attitude based upon the age of the teachers. The table shows that younger teachers have more positive attitudes and that older teachers have more negative attitudes. Age seemed to make no difference in discriminatory attitudes or expression of competence to supervise instructional computing.

CONCLUSION

The following assumptions, confirmed by recent research, undergird this study. Successful change can accompany innovations only if they fit easily within the existing school structure and teachers view the change as meaningful and not too hard to implement (Berman, 1981). The culture of teaching has its own set of restrictions which manifest themselves in daily classroom life and in administrative demands placed on teachers (Cuban, 1986; Jackson, 1978; Weinshank et al., 1983). As final arbitrators of classroom activities, regardless of administrative mandates, teachers will shape any implementation effort to fit their own situations (Fullan, 1982). Teachers' attitudes have an influence on instructional computing, just as on every other aspect of classroom life; more positive attitude promotes while more negative inhibits instructional computing (Weinshank et al., 1983). The shortage of computers within the schools highlights the fact that teachers' attitudes influence quantitative and qualitative access to computers. Teachers are in a position to decide how, for what purpose, when, and by whom the computers are used. Educational research has a history of excluding the teacher's viewpoint from studies about school change (Cuban, 1986; Weinshank, et al., 1983).

This study confirmed the above assumptions and concludes that a successful and ongoing implementation effort begins by including the teachers in studies about what happens in their classrooms. Furthermore, the combined top-down, bottom-up approach that employs key individuals ranging from school administrators to community members to place and use computers both at home and in the schools, has clear advantages over the unbalanced, unfortunate implementation efforts that have failed in the past simply because it includes the teachers in the plan from conception to realization.

This study was limited to Wisconsin sixth grade teachers in the Spring of 1985 and cannot be extrapolated to other states or situations. Results showed that teachers were unclear about the goals of instructional computing and therefore that they had difficulty attaching any real, supportive meaning to the innovation. For many, the program's most valuable aspect was not its educational benefits, but simply "motivation." Many teachers complained about the difficulty of merging the computer into existing time and classroom patterns, about the shortage of equipment, and about the lack of training; all of these indicate dangers to smooth classroom implementation.

Quantitative and qualitative inequities regarding instructional computing were confirmed in this study. Most schools had computers but resources were distributed unequally within school districts. Forty-three percent of the teachers reported some student requirements for instructional computing, while some teachers reported that their schools did not have any computers at all. In schools with computers, students' access varied greatly within classrooms, from zero days to the entire school year, and seemed to depend to a certain degree upon the enthusiasm of particular classroom teachers. Less than fifty percent of students used computers regularly in the large majority of cases. Students who were most likely to use a computer within a classroom were those who had finished their other work, were interested, competent, above average, or had a computer at home. Although many teachers suggested "equal access" as a criterion for allocating access to the computers, patterns of usage and opinions of other teachers revealed that access was being directed toward specific groups of students, such as advanced, remedial, or those who are well-behaved.

Teachers reported that although students of average ability had the highest patterns of usage, advanced students were engaged in more high-level, cognitive excercises with the computers, while average and remedial students were engaged in lower-level activities, such as drill and practice. This measurement had room for error because it required teachers to estimate usage patterns; it is quite possible that the regular classroom teachers are unaware of the kind of activities gifted or remedial students engage in while attending specially funded classes. It would be better to measure usage between student groups by more precise methods during the course of those activities rather than having teachers try to estimate usage patterns from memory.

The teachers' attitudes and opinions about the goals, values, and general validity of instructional computing varied widely and reflected general confusion about the program. In general, teachers believed that students do not receive enough practice to become competent users and that access to computers should be determined on the basis either of equity, or of preference for better trained teachers, or of a motivational reward system, or of remedial reinforcement. Approximately one fourth of the teachers believed that inadequate teacher training, teacher apathy, or lack of an organized program were deterrents to adequate instruction and practice time. This emphasizes the need for planning and setting direction for instructional computing, and underlines the theory that skeptics or those resistant to change must see positive results with an innovation to be motivated to incorporate that innovation into their own teaching (Cuban, 1986; Fullan, 1982).

Motivation was seen as the most beneficial aspect of instructional computing, followed by preparing students for life in a changing society, increased learning, and job preparation skills. In contrast, some teachers believed there was no benefit at all to instructional computing. Many teachers claimed that the worst aspects of instructional computing were the shortage of equipment, time constraints of the daily schedule, inadequate teacher training, and lack of program direction. In addition to these complaints, teachers mentioned the difficulty of managing and supervising computer usage, and the inappropriateness of software to curricular needs.

About one third of the teachers in this sample had not used computers at school, mostly due to lack of training, shortage of computers, or scheduling and management problems caused by remote location of the machines. Those teachers who used computers and those who had not expressed common problems and concerns, but responded differently to them. Teachers who had not used computers reflected attitudes that were more negative, more discriminatory, and more insecure about the competence to use a computer for instructional purposes, than those expressed by teachers who had supervised computer use. Nonusing teachers were more resistant or ambivalent toward computers than the users. In fact, the nonusing group contained a few teachers who just plain refused to recognize any value to instructional computing and therefore refused to use computers at all.

Teachers who used computers were conditional accepters; they were willing enough to use the machines, but their experience had been difficult enough to cause some doubts and to lead to inequitable decisions, especially in allocating particular types of software to student ability groups. Their complaints were more sophisticated, as their knowledge and experience on the machines was greater.

The mixture of user and nonuser teachers within the school will probably magnify the existing confusion about the objectives of instructional computing and the frustration with implementing it; this can promote both quantitative and qualitative inequity among students. And if a school had teachers who were all users, then the inequities would be related more to curricular problems and technical support.

Age also affected teacher attitudes toward implementation of instructional computing; younger teachers expressed more positive attitudes. This is consistent with results of a study by the Rand Corporation which document that the length of the teaching career is negatively associated with successful implementation of changes; older, more experienced teachers were less likely to change their teaching practices (Berman & McLaughlin, 1978).

Studies about instructional media, including radio and television, cite lack of equipment, lack of training, inconvenience, and no relevancy to the standard curriculum as major reasons why the media were not used either daily or, in some cases, on any regular basis (Cuban, 1986). This study showed that teachers believed these same four issues were highly problematic for instructional computing. If previous experience is a guide, then the future success of computers in the elementary schools cannot be guaranteed without supportive teachers who are committed to the instructional computing program. Commitment, understanding of the goals, resources, and skills are directly related to successful change and implementation of innovations within schools (Sarason, 1982).

This study suggests a need to investigate methods of setting goals for both instructional computing and provision of teacher training. Whereas previous technological innovations had mostly top-down implementation efforts in the schools, with pressure coming from the administration to implement, computers have been a mix of a top-down, bottom-up approach in which teachers have been involved in the effort (Cuban, 1986; Sheingold et al., 1981). We need to know how teachers determine goals for instructional computing and communicate those goals to other teachers. This study provided a rough look at training, but a more detailed, indepth investigation is necessary to determne what kinds of training opportunities teachers have and the effectiveness of training when it is applied to the classroom situation.

The provision of training and better equipment is not enough, however. Training should be tailored to the classes of opinion and attitude that already exist in the school, to bring users and nonusers closer together, to answer their specific complaints, to enhance familiarity among current nonusers and to encourage and support current users. Such an effort might decrease the inequitable decisions that arise under the conditions reported in this study. One model for change and implementaton will not suit all situations, but any effort at change needs to be tailored to specific situations. Different diffusion patterns have been noted as teachers tailor innovations to meet their own classroom environment (Cuban, 1986; Fullan, 1982). A good start would be to follow the example set by the St. Paul, Minnesota school district, which trained a cadre of teachers, who agreed in turn to train other teachers within their school district. This sort of "train the trainer" approach has great potential for schools because teachers would be brought together to support each other through training and during the process would undoubtedly set some goals for instructional computing as well. In such an approach teachers could address the real problems they are having in the classroom, offer realistic solutions, acknowledge ownership of the problems, and infuse real meaning to the program. The bottom-up effect of such a plan, combined with the top-down interest necessary to get it started and support the effort would give the implementation approach a good chance of success.

REFERENCES

Alvarado, A. J. (1984, April). Computer Education for ALL Students. *The Computing Teacher*, 11 (8), 14-15.

Anderson, R. E., Welch, W. W. and Harris, L. J. (1984, April). Inequities in Cpportunities for Computer Literacy. *The Computing Teacher*. 11 (8), 10-12.

Becker, H. J. (1982, January). *Microcomputers in the Classroom--Dreams and Realities*. Baltimore, Maryland: Center for Social Organization of Schools, John Hopkins University.

Becker, H. J. (1984). School Uses of Microcomputers: Report #3 from a National Survey. *The Journal of Computers in Mathematics and Science Teaching*, III (3), 26-32.

Becker, H. J. (1985, March). *How Schools Use Microcomputers: Summary of the First National Survey*. Center for Social Organization of Schools, The Johns Hopkins University.

Becker, H. J. (1986a, June). *Instructional Uses of School Computers. Reports from the 1985 National Survey. Issue Number 1*. Center for Social Organization of Schools, The Johns Hopkins University.

Becker, H. J. (1986b, August). *Instructional Uses of School Computers. Reports from the 1985 National Survey. Issue Number 2*. Center for Social Organization of Schools, The Johns Hopkins University.

Berman, P. (1981). Toward an Implementation Paradigm. In R. Lehming and M. Kane (Eds.), *Improving Schools*. Beverly Hills, CA: Sage.

Berman, P. & McLaughlin, M. (1976). Implementation of Educational Innovation. *Educational Forum*, 40 (3), pp. 345-370.

Berman, P. & McLaughlin, M. (1978). *Federal Programs Supporting Educational Change, Vol. VIII, Implementing and Sustaining Innovations*. Santa Monica, California: Rand Corporation.

Cuban, L. (1986). *Teachers and Machines: The Classroom Use of Technology Since 1920*. New York: Teacher's College Press.

Edwards, C. (1984, April). Achieving Equity. *The Computing Teacher*, 11 (8), 62-64.

Enochs, L. G. (1984). The Effect of Computer Instruction on General Attitudes toward Computers of Fifth Graders. *The Journal of Computers in Mathematics and Science Teaching*, III (3), 24-25.

Fisher, G. (1984, April). Access to Computers. *The Computing Teacher*, 11 (8), 24-27.

Fullan, M. (1982). *The Meaning of Educational Change*. New York: Teachers College Press.

Jackson, R. (1978). *Implications of Declining Enrollment for the Schools of Ontario: A Statement of Effects and Solutions*. Final report of the Commission on Declining Enrollments. Toronto: Ontario Ministry of Education.

Lacina, L. J. (1984, Winter). Computer Equity in Public Eduction. *Education*, 104 (2), 128-130.

Lesgold, A. M., & Reif, F. (1983, June). *Computers in Education: Realizing the Potential*. Chairmen's Report of a Research Conference, Pittsburgh, Pennsylvania, November 20-24, 1982. Washington, D. C.: U. S. Government Printing Office.

Lortie, D. (1975). *Schoolteacher: A Sociological Study*. Chicago: University of Chicago Press.

Miles, M. (1980). School Innovation from the Ground Up: Some Dilemmas. *New York University Education Quarterly*, 11 (2), 2-9.

Sarason, S. B. (1982). *The Culture of the School and the Problem of Change*. Boston, Massachusetts: Allyn and Bacon, Inc.

Schubert, J. G. and Bakke, T. W. (1984, April). Practical Solutions to Overcoming Equity in Computer Use. *The Computing Teacher*, 11 (8), 28-30.

Sheingold, K., Kane, J., Endreweit, M., and Billings, K (1981, February). *Issues Related to the Implementation of Computer Technology in Schools: A Cross-Sectional Study*. New York: Bank Street College of Education.

Weinshank, A. B., Trumbull, E. S., & Daly, P. L., (1983). The Role of the Teacher in School Change. In L. S. Shulman & G. Sykes (Eds.), *Handbook of Teaching and Policy*. New York: Longman.

TABLE 1

Do Students Receive Enough Instruction and Practice to Become Competent?

VARIABLE	N	%
Yes	81	23
No	271	77
TOTAL	352	100

If No, Why Not?	N	%*
Not Enough Access to Computers	155	57.2
Can't Take Time from Curriculum	148	54.6
Teacher Training or Apathy	77	28.4
No Organized Program	64	23.6
Type of Available Software	14	5.2
Dif. Brand or Incompatible Equipment	3	1.1
No Student Interest	2	.7

* Respondents = 271. Total Percent is greater than 100 because teachers wrote more than one answer.

TABLE 2

How Many Students Use Computers on a Regular, Weekly Basis?

REGULAR STUDENT USERS	N	%
10% or Less	142	40.3
11 - 25%	75	21.3
26 - 50%	64	18.2
More than 50%	71	20.2
TOTAL	352	100.

Reasons Less Than 50% Students Use Computers Weekly

VARIABLE	N	%*
Choices		
Central Location Limits Use	168	61.1
Can't Take Time from Regular Curric.	161	58.5
Teachers Not Trained	160	58.2
Funds Limit to Specific Student Group	32	11.7
Funds Limit to Curric Area	15	5.5
Write-Ins		
Lack Enough Computers	51	18.5
Lack Necessary Software	27	9.8
Undeveloped Program	20	7.3
Lack of Student Interest	7	2.5

Respondents = 275

* Total Percent is greater than 100 because teachers indicated more than one answer.

TABLE 3

Which Students Use Computers in Classrooms?

DO ALL STUDENTS IN CLASS USE PERIODICALLY?	N	%
Yes	168	72.4
No	64	27.6
TOTAL	232	100.

IF NO, WHICH STUDENTS ARE MORE LIKELY TO USE?	N	%
Finished with Work, Interested, Competent	14	21.8
Those Interested	13	20.3
Above Average With Interest	12	18.7
Have Computer at Home	10	15.6
Remedial, Poorly Motivated	5	7.8
Advanced Boys	4	6.3
Gifted or Remedial	4	6.3
Good Behavior	1	1.6
More Aggressive	1	1.6
TOTAL	64	100.

TABLE 4

Type of Usage by Student Groups - Percentages & ANOVA

VARIABLE	GIFTED		AVERAGE		REMEDIAL	
	MEAN	SD	MEAN	SD	MEAN	SD
Write Programs	11.4	20.9	6.9	15.6	2.2	9.9
Word Processing	7.7	14.8	8.5	19.5	2.5	8.8
Tutorial	5.1	10.3	8.9	12.9	9.1	16.2
Drill & Practice	13.7	21.7	31.8	23.6	26.8	28.6
Demonstration	2.7	6.4	3.9	7.7	2.7	6.8
Simulation	7.3	14.4	7.1	12.6	2.7	8.1
Games	20.5	27.0	29.2	26.1	17.0	22.8
Spreadsheets	.1	.7	.0	.1	--	--
Data Base	.4	2.7	.8	5.0	.1	.9
Telecommunications	.0	.3	--	--	--	--
Robotics	.3	3.2	.1	.9	--	--
Other	.1	.5	.2	1.7	.1	.7

FRIEDMAN TWO-WAY ANOVA: Total Usage Between Student Groups

VARIABLE	MEAN RANK	CHI-SQUARE	DF	SIGNIFICANCE
SUM OF USE FOR:		38.26	2	.00
Gifted	1.89			
Average	2.31			
Remedial	1.80			

N = 251

TABLE 5

Percentages of Usage Sorted by High- and Low-Level Skills

VARIABLE	MEAN	SD	MAX
HIGH LEVEL			
Write Programs	6.79	12.16	100.00
Word Processing	6.18	11.23	83.33
Simulation	5.67	9.12	53.33
MEAN TOTAL	6.21	6.44	43.89
LOW LEVEL			
Tutorial	7.69	10.09	50.00
Drill & Practice	24.01	19.48	100.00
Demonstration	3.10	5.70	30.00
MEAN TOTAL	11.60	7.93	33.33

Minimum = .00

N = 251

TABLE 6

Percentages of High & Low Level Usage by Student Groups

VARIABLE	GIFTED		AVERAGE		REMEDIAL	
	MEAN	SD	MEAN	SD	MEAN	SD
High Level	26.21	30.76	22.40	29.99	7.29	15.81
Low Level	21.48	27.56	44.73	28.11	38.36	36.61

N = 251

TABLE 7

Wilcoxon Matched-Pairs Signed-Ranks Tests of High-Level Use Between Gifted, Average and Remedial Student Groups

GIFTED HIGH LEVEL WITH AVERAGE HIGH LEVEL	MEAN RANK	N
- Ranks (Average High < Gifted High)	78.17	106
+ Ranks (Average High > Gifted High)	91.67	59
Ties (Average High = Gifted High)		86
Z = -2.34		
P = .01		
GIFTED HIGH LEVEL WITH REMEDIAL HIGH LEVEL	**MEAN RANK**	**N**
- Ranks (Remedial High < Gifted High)	69.01	124
+ Ranks (Remedial High > Gifted High)	39.28	9
Ties (Remedial High = Gifted High)		118
Z = -9.21		
P = .00		
AVERAGE HIGH LEVEL WITH REMEDIAL HIGH LEVEL	**MEAN RANK**	**N**
- Ranks (Remedial High < Average High)	73.48	138
+ Ranks (Remedial High > Average High)	63.50	7
Ties (Remedial High = Average High)		106
Z = -9.57		
P = .00		

TOTAL N = 251

TABLE 8

Wilcoxon Matched-Pairs Signed-Ranks Tests of Low-Level Use Between Gifted, Average and Remedial Student Groups

GIFTED LOW LEVEL WITH AVERAGE LOW LEVEL	MEAN RANK	N
- Ranks (Average Low < Gifted Low)	47.00	10
+ Ranks (Average Low > Gifted Low)	92.03	168
Ties (Average Low = Gifted Low)		73
Z = -10.89		
P = .00		
GIFTED LOW LEVEL WITH REMEDIAL LOW LEVEL	**MEAN RANK**	**N**
- Ranks (Remedial Low < Gifted Low)	69.92	26
+ Ranks (Remedial Low > Gifted Low)	73.67	119
Ties (Remedial Low = Gifted Low)		106
Z = -6.86		
P = .00		
AVERAGE LOW LEVEL WITH REMEDIAL LOW LEVEL	**MEAN RANK**	**N**
- Ranks (Remedial Low < Average Low)	106.53	95
+ Ranks (Remedial Low > Average Low)	75.09	87
Ties (Remedial Low = Average Low)		69
Z = -2.52		
P = .01		

TOTAL N = 251

TABLE 9

Best Aspects of Instructional Computing

VARIABLE	N	%*
Motivation - Interest, Challenge, Reward, Change of Pace	117	40.2
Future - Technology, Keep With Times, Society, Awareness	56	19.2
Helps or Increases Learning	33	11.3
Job Prep. - Typing, Word Processing, Job & Life Skills	29	10.0
Nothing Good About It	20	6.9
Remediation	19	6.5
Individual Level	19	6.5
Logic - Problem Solving, Critical Thinking	17	5.8
Variety - Potential Versatility of Software	14	4.8
Enrichment for Advanced	11	3.8
Relevant Extension of Basics - Drill	10	3.4
Age - Can begin early to develop sophistocated skills	5	1.7
Independent Tool - Can do it Without Teacher	5	1.7
Not Mandatory - Optional for Teachers	5	1.7
Mandatory - Teachers Must Learn, Forces Me	3	1.0

No Response = 78
Valid Cases = 291

* Total Percent is greater than 100 because teachers indicated more than one answer. (All write ins)

TABLE 10

Criteria Suggested by Teachers for Determining Access

VARIABLE	N	%*
Equal Access - All Students have equal access	93	36.9
Better Teachers - Trained Teachers Get First Choice	68	27.0
Motivation - Reward, If no behavior problems	65	25.8
Need - Remedial Reinforcement	62	24.6
Ability - Above Average, Enrichment, Independent Workers	49	19.4
Interest - Those Interested, First Come	46	18.3
Older Students Should Have Priority	26	10.3
Would Not Use Computers	9	3.6

N = 252

* Total percentage is greater than 100 because teachers indicated more than one response.

TABLE 11

Worst Aspects of Instructional Computing

VARIABLE	N	%*
Lack Equipment, Software, Space	107	36.5
Daily Schedule - Lack Time, Neglect Basics	74	25.3
Inadequate Teacher Training	60	20.5
Lack Program Direction	52	17.7
Poor Quality Software	32	10.9
Too Expensive, Can't Afford, Not Justified	32	10.9
Lack Prep. Time to Plan and Select Software	28	9.6
Questionable Educational Value	24	8.2
Misuse - Students Only Interested in Games, Use as a Toy, Lazy, Waste Time	17	5.8
Teacher Apathy or Fear of Change	12	4.1
Misconception that it will Solve Instructional Problems or that we all Need it	11	3.8
Hard to Supervise, Equipment Easily Damaged	10	3.4
Dehumanizing, Isolating	4	1.4
Defective Equipment - Hardware or Software	3	1.0
Distraction to Class	3	1.0
Inequitable - Only Learn if Teacher Interested	1	0.3

No Response = 76
Valid Cases = 293

* Total Percent is greater than 100 because teachers indicated more than one answer. (All write ins)

TABLE 12

Major Problems Experienced in Your School

VARIABLE	N	%*
Lack Time	131	47.6
Lack Computers	101	36.7
Lack Teacher Training	90	32.7
Hard to Supervise Use & Grade	65	23.6
Lack Program Objectives	64	23.3
Lack Quality or Appropriate Software	52	18.9
Remote Locations	21	7.6
No Teacher Interest	16	5.8
Lack Administrative Support or Funds	12	4.4

Valid Cases = 275

* Total Percent is greater than 100 because teachers indicated more than one answer.

TABLE 13

Have You Supervised Computer Use This School Year?*

VARIABLE	N	%
Yes	226	64.2
No	116	35.8
TOTAL	352	100.

Reasons Given for Having Not Supervised Computer this year

VARIABLE	N	% **
Not Enough Training to Feel Comfortable	81	64.3
Lack Computers to Schedule All	76	60.3
Difficult to Schedule in Other Room	60	47.6
Can't Supervise in Remote Location	43	34.1
Lack Desire	22	17.5
Write Ins		
Another Adult Supervises My Students	19	15.1
Lack Time from Curriculum	12	9.5
Restricted to Other Uses	9	7.1
Lack Appropriate Software	2	1.6

Respondents = 126

* Includes only teachers in school with computers

** Total Percent is greater than 100 because teachers indicated more than one answer.

TABLE 14

Opinion Differences by Age, Sex, Use/Nonuse*

SUBJECT	VARIABLE	SUGGESTED MORE BY
Access Criteria	Equal Access	Females
	Need, Remedial	Age 51/Older
	Student Ability	Nonusers
Best Aspects	Job Preparation	Males
	Nothing Good	Nonusers
Worst Aspects	Preparation Time	Females
	Lack of Equipment	Age 35/Younger
	Questionable Value	Age 51/Older
Major Problems	Remote Location	Age 35/Younger
	Management	Age 35/Younger
	Teacher Interest	Age 36 - 50
	Lack of Software	User
	Lack of Training	Nonuser

* All relationships significant at alpha .05 or less

TABLE 15

T Tests on Attitudes Noted Between Users and Nonusers; Age Groups

VARIABLES	N	M	SD	DF	T	P
POSITIVE*						
Nonuser	143	11.72	2.97			
User	226	9.65	2.83	291.28	6.64	.000
40 or Younger	176	9.99	2.90			
41 or Older	193	10.87	3.14	366.96	-2.79	.006
NEGATIVE*						
Nonuser	143	16.15	3.78			
User	226	18.10	3.98	313.71	-4.74	.000
40 or Younger	176	18.10	3.95			
41 or Older	193	16.65	3.96	364.11	3.52	.000
DISCRIMINATORY*						
Nonuser	143	23.93	4.83			
User	226	25.85	4.63	292.47	-3.79	.000
COMPETENCY*						
Nonuser	143	32.18	5.94			
User	226	28.01	5.73	294.02	6.67	.000

* Lower Means are more strongly positive, more strongly negative, more strongly discriminatory, and more competent.

INSTRUCTIONAL COMPUTING (IC) QUESTIONNAIRE

1. How would you characterize each of the following groups in your community in terms of their support for IC? Use the following scale:
5 = Very strong support; 4 = Strong support; 3 = Moderate support;
2 = Weak support; 1 = Very weak support: (write a number in each box)

☐School board ☐District administrators ☐Principal ☐Teachers
☐Students ☐Parents ☐YOU

2. Does your school use computers for instruction? ☐YES ☐NO
IF YES, answer 'a - n' below; IF NO, skip to question 5:

a. How many computers does your school have?____________________

b. Check 1 statement that most accurately reflects your school's situation:
☐ We need more computers.
☐ We have just the right number of computers.
☐ We have too many computers; those we have frequently sit idle.

c. Does your school have a written, formal plan for:

	YES	UNDER DEVELOPMENT	NO	DON'T KNOW
1. Instructional uses of microcomputers?	☐	☐	☐	☐
2. Computer literacy curriculum?	☐	☐	☐	☐
3. Implementation of computer education?	☐	☐	☐	☐

d. Are all students required to learn the use of computers? ☐YES ☐NO

e. Are your students given a separate grade for their work with computers?
☐YES ☐NO

f. In general, what percentage of students use computers on a regular, weekly basis? (Check ONE box below)
☐10% or less ☐11-25% ☐26-50% ☐More than 50%

IF YOU ANSWERED LESS THAN 50% above, indicate reasons why more students do not receive instructional computing weekly. (Check ALL that apply)

☐ Specific funds restrict IC to special student groups (eg. gifted)
☐ Specific funds restrict IC to special curricular area (eg. science)
☐ Teachers are not adequately trained in the use of computers
☐ Computers are "centralized" in a few areas and access is difficult
☐ We can't take time from the regular curriculum
☐ Other ____________________

g. Do you feel that most students receive enough instruction and practice time to truly become competent at and comfortable using computers?
☐YES ☐NO

IF NO, why not?

h. Is IC integrated with the basic curriculum? ☐YES ☐NO
IF YES, in which subject areas?____________________

2. continued

i. How is access determined?
- ☐ Students elect to use the computer; mark those that apply:
  - ☐ Rotating schedule for equal amounts of time (eg. 10 min. shifts)
  - ☐ Students who finish their work first use the computer.
  - ☐ Regardless of finished work, first-come, first-served.
  - ☐ Other, please explain ______________________________

- ☐ Teacher assigns students to use the computer; mark those that apply:
  - ☐ Specific groups (eg. Assignment for entire reading or math class, etc., by group)
  - ☐ Remedial students mostly are assigned
  - ☐ Advanced students mostly are assigned
  - ☐ Other, please explain ______________________________

j. Does the district require computer training for teachers? ☐ YES ☐ NO

k. Check ALL statements below which describe the way your school acquired microcomputers:
- ☐ Solely upon administrative recommendation
- ☐ After 5 or more planning sessions including teachers
- ☐ Before teachers were trained to operate the computers proficiently
- ☐ Before teachers knew how to assimilate CAI into their teaching
- ☐ Hardware purchases were based upon particular software needs which had been determined by a curriculum plan

l. About how many meetings did you attend to plan for computer implementation before your school purchased computers? (Check one)
☐ 0 ☐ 1-2 ☐ 3-4 ☐ 5-6 ☐ 7-8 ☐ Other, specify ________

m. What are some of the major problems you've had with instructional computing, and what solutions have you tried?

n. In the matrix below, estimate the percentage of total computer time spent on the various TYPES of IC for each of the FOUR STUDENT GROUPS:

	GIFTED/TALENTED	AVERAGE	REMEDIAL	HANDICAPPED
Writing programs				
Word processing				
Tutorial				
Drill and Practice				
Demonstration				
Simulation				
Instructional Games				
Spreadsheets				
Databases				
Telecommunications				
Robotics				
Other				
TOTAL	100%	100%	100%	100%

3. Have YOU supervised computer use while teaching this year? [ ]YES [ ]NO
IF YES, answer 'a - j': IF NO, skip to question 4:

a. Where are those computers located?
[ ] Computer Lab [ ]IMC [ ] Your classroom

b. List the numbers of computers ______, and students______ in the room.

c. About how many students are assigned per computer? ________________

d. How often does the average student "use a computer" in that setting?
[ ] Daily
[ ] Twice per week
[ ] Once per week
[ ] Once every two weeks
[ ] Once per month
[ ] Other ______________________________

e. Approximately how long (in minutes) does each student "use a computer" per session? ______________________________

f. Do all students in your class use computers at periodic intervals?
[ ]YES [ ]NO

IF NO, which students are likely to use the computers?

g. How do you usually use computers in instruction? (Check ALL that apply.)
[ ] I incorporate computers into unit plans for teaching certain subject areas. Which subjects?______________________________
[ ] I use computers independently of other subjects being taught.
[ ] I treat computers as a separate subject (eg. Teach about computers)

h. While part of the class uses computers, the other students are usually engaged in: (check ONE box)
[ ] A related activity (eg. Computer group does math drill while others do math worksheet practicing the same concept)
[ ] An unrelated activity (eg. Computer group does math drill while others do science reports)
[ ] There are enough computers for all students to use them at once.

i. The method I use for recording computer use is: (Check ALL that apply)
[ ] With my guidance, students keep their own records.
[ ] I do not keep records.
[ ] I keep records of time spent on a computer by each student.
[ ] I keep records of software used by each student.
[ ] I keep records of scores earned on software programs.
[ ] I evaluate programs that students write
[ ] Other, please explain ______________________________

j. IF THE COMPUTERS ARE LOCATED IN YOUR CLASSROOM, answer 1 - 3 below:

1. How long can you keep the computers in your room? (Check one box)
[ ] One week
[ ] Two weeks
[ ] One month
[ ] One semester
[ ] Entire school year
[ ] Other, specify ____________________

3. j. continued

2. In general, how often are the computers used?
   [ ]Daily [ ]Once every two weeks
   [ ]Twice per week [ ]Once per month
   [ ]Once per week [ ]Other____________________

3. In general, how many hours are the computers actually used during each day that they are turned on? ____________________

4. If you HAVE NOT supervised computer use during this school year, check all below that indicate why not:
   [ ] I don't like to use computers.
   [ ] I haven't had enough training to feel comfortable using computers.
   [ ] I hesitate to send students from my class to use computers where I cannot supervise them.
   [ ] Scheduling students to use computers in other rooms difficult
   [ ] There are not enough computers for all students in my class to use the machines in time allowed
   [ ] Other____________________

5. How many meetings have you attended during this school year to plan for computer implementation? (Check ONE box below)
   [ ]0 [ ]1-2 [ ]3-4 [ ]5-6 [ ]7-8 [ ]Other, please specify________

6. In your judgment, do students learn better individually or in groups when using computers? [ ]INDIV [ ]GROUPS

7. If students are "grouped" on machines, do you feel the IC is truly individualized? [ ]YES [ ]NO [ ]UNCERTAIN

8. Suppose you worked in a school which did not have enough computers for all students to use. List 2 or 3 criteria you would use to determine access to the machines. Please EXPLAIN your answer.

9. Check any special training you have had about microcomputers or IC?
   [ ] Teacher Inservice - How many hours?__________
   [ ] Technical School - How many full semester courses? __________
   [ ] College - How many computer credits? __________
   [ ] Local computer classes offered by businesses or private persons in the area - How many hours?__________
   [ ] Other, please explain __________

10. If you were not responsible for teaching with computers, would you take a computer class? [ ]YES [ ]NO

11. Do you have a computer at home? [ ]YES [ ]NO
    IF YES, why did you purchase it?____________________

12. Do you belong to a computer users group? [ ]YES [ ]NO

Mark one box per line to indicate how you feel about each of the following statements concerning CAI; Use the following scale: SA = STRONGLY AGREE A = AGREE U = UNDECIDED D = DISAGREE SD = STRONGLY DISAGREE

13. Microcomputers for student use:	SA	A	U	D	SD
a. Are a welcome addition to school curricula	☐	☐	☐	☐	☐
b. Are a necessary investment for schools	☐	☐	☐	☐	☐
c. Complicate my job more than I'd like	☐	☐	☐	☐	☐
d. Enhance the quality of education	☐	☐	☐	☐	☐
e. Take too much time away from the basic subjects	☐	☐	☐	☐	☐
f. Are a fad whose popularity will fade	☐	☐	☐	☐	☐
h. Are very helpful in teaching language arts	☐	☐	☐	☐	☐
i. Should be taught as a separate subject	☐	☐	☐	☐	☐
j. Are more appealing to boys than to girls	☐	☐	☐	☐	☐
k. Are more necessary for boys than for girls	☐	☐	☐	☐	☐

14. I have enough skill to feel comfortable teaching:	SA	A	U	D	SD
a. With computers (using software).	☐	☐	☐	☐	☐
b. About how a computer works (basic logic).	☐	☐	☐	☐	☐
c. BASIC programming on an introductory level.	☐	☐	☐	☐	☐
d. BASIC programming on an advanced level.	☐	☐	☐	☐	☐
e. Pascal programming	☐	☐	☐	☐	☐
f. Logo	☐	☐	☐	☐	☐
g. Using telecommunications	☐	☐	☐	☐	☐
h. Using robotics	☐	☐	☐	☐	☐
15. Handicapped children are not likely to become very good at using computers.	☐	☐	☐	☐	☐
16. The limited number of student computers presents problems in scheduling access for ALL students.	☐	☐	☐	☐	☐
17. More computers would:					
a. Promote access for more students	☐	☐	☐	☐	☐
b. Ease scheduling of CAI for my classes	☐	☐	☐	☐	☐
c. Be difficult to supervise	☐	☐	☐	☐	☐

18. Priority for IC should be given to:	SA	A	U	D	SD
a. Gifted and talented students.	☐	☐	☐	☐	☐
b. Remedial students.	☐	☐	☐	☐	☐
c. Those who finish their other work early.	☐	☐	☐	☐	☐
d. Those students in a computer club.	☐	☐	☐	☐	☐

19. Computers should be reserved for teaching:	SA	A	U	D	SD
a. Math, science & social studies only	☐	☐	☐	☐	☐
b. Language arts and reading only	☐	☐	☐	☐	☐
c. BASIC or Logo programming only	☐	☐	☐	☐	☐
d. In many subjects, but without programming	☐	☐	☐	☐	☐
e. In many subjects, with programming	☐	☐	☐	☐	☐
f. At the high school level, since mature students will better understand computing in general	☐	☐	☐	☐	☐
20. Most educational software is:					
a. Of inferior quality and lacks good content	☐	☐	☐	☐	☐
b. More appealing to boys than to girls	☐	☐	☐	☐	☐

	SA	A	U	D	SD
21. Money spent on instructional computing at the elementary school level would be better spent in other curricular areas, for other materials	☐	☐	☐	☐	☐
22. Our principal seems:					
a. Knowledgable about computer education	☐	☐	☐	☐	☐
b. Helpful concerning computer implementation	☐	☐	☐	☐	☐
c. Interested in computers, but lacks necessary knowledge to help me implement them	☐	☐	☐	☐	☐
d. Uninterested in computer education	☐	☐	☐	☐	☐

23. In general, the best thing about computer education is:

24. In general, the worst problem with computer education is:

25. Check the statement that describes your school district:
- ☐ Urban (city of 50,000 or more)
- ☐ Suburban (adjacent to a city of 50,000 or more)
- ☐ Medium city (city of 15,000 - 49,999)
- ☐ Small city (city of 3,000 - 14,999)
- ☐ Rural (less than 3,000)

26. Please estimate the racial composition of your school by percent.
___Black ___Hispanic ___ Asian ___Native American ___White ___Other

27. How many years have you been teaching? (include this year) ________________
28. How many years have you taught at this school? (include this year) ________
29. List any administrative duties you perform ________________________________
30. Your sex? ______________
31. Your age? ______________
32. Name & phone number (optional) ____

THANK YOU VERY MUCH for taking the time to answer these questions!

PLEASE RETURN TO:

Nancy Knupfer
207 Bacon Street
Waunakee, WI 53597

Schema Activation and Pre-instructional Strategies

Rengen Li
The Florida State University
206 Dodd Hall, LSI, FSU
Tallahassee, FL 32306

Running heading: Schema activation

A number of advocators of schema theory have defined schema differently. Here we considered a schema as "an organized body of knowledge, conceived theoretically as a set of interconnected propositions centering around a general concept, and linked peripherally with other concepts" (Gagne, 1986). According to this definition, a schema may be an integrated structure of knowledge about a certain topic or content. There may exist a great number of schemata representing different aspects of this knowledge, and these schemata of different aspects may have also numerous subschemata representing the sub-domains of this knowledge (Gagne, 1977).

WHAT DOES RESEARCH SAY ABOUT SCHEMA?

1. The learner's existing schema related to the learning topic plays a critical role in new learning.

The learner's pre-existing related schema affects both comprehension and memory. It is well studied that if a learner does not possess a well developed schema related to the learning topic, he or she could not well comprehend or remember the new information. When subjects were provided with related knowledge or with ways to link the new information to the subjects' prior knowledge, their comprehension and memory are greatly improved (Bransford & Johnson, 1972; Royer & Cable, 1975, 1976). Grade school students with appropriate background could learn more than did graduate students and university faculty members who did not have that background, and the subjects with more knowledge about baseball recalled substantially more of the baseball narratives presented than did those with less baseball prior knowledge (Chi, 1978; Chiesi, Spilich, & Voss, 1979; Spilich, Vesonder, Chiesi, & Voss, 1979).

Learners with different background comprehend the same story differently. Given a story from a particular culture, students from a different culture recalled the story distortionally. But their reoproduction was skewed toward the direction of their own culture and more information consistent with their own cultures was recalled (e.g., Bartlett, 1932; Steffensen, Joag-dev & Anderson, 1979; Aron, 1985). Asking students of different majoring areas to read an ambiguous passage, the researchers found the subjects' interpretations of the same story were based on their backgrounds and experiences (Anderson, Reynolds, Shallert & Goetz, 1977; Anderson & Acker, 1984).

It has been found that the learner's pre-existing schema affects the whole learning process. First, schema could influence the amount of attention allocated to a particular type of information. Secondly, it could determine what information is selected for processing. Thirdly, it could intergrate the new information and produce an integrated body of the new and old information learned. And lastly, it guides the process of retrieving to locate the information retained in memory (Brewer & Nakamura, 1984; Alba & Hasher, 1983).

2. Prior to or during learning, appropriate schemata should be activated in order to produce best learning results.

Learners' pre-existing schemata are necessary but not sufficient for new learning. More important is the activation of the schemata prior to and during learning. Research literature suggests that the first stage of schema function in learning process is schema recognition (Graesser & Nakamura, 1982) or schema access (Cunningham, 1984). Before a learner begins to read a passage, he or she must recognize an appropriate schema for that passage. When no cues are provided to help activate such a schema, the learner has to induce one. The difference of comprehension and memory between the conditions in which an appropriate schema is activated and those in which no schema is activated has been found substantial. For example, students given a context before reading an ambiguous passage greatly improved their comprehension and recall because they identified, and therefore activated, an appropriate schema (Bransford & Johnson, 1972). Similar results have been reported with different ways to activate students' prior schemata such as context information (Schallert, 1976; Townsend, 1980), titles (Kozminsky, 1977) and pre-passage questions (Wilhite, 1983). Furthermore, students with different types of schemata activated would remember different types of information. For example, the learners with a home buyer perspective recalled more items related to the value of the house, while those with a burglary perspective recalled more items which are interesting to a burglar. When these subjects switched their perspectives, they recalled items that were consistent with the new perspectives and that they failed to recall before (Anderson, Pichert, and Shirey, 1983).

On the other hand, activating an inappropriate schema sometimes has negative effects on learning. For example, when students were given inappropriate contextual information, they recalled less information than did those who were given no contextual information (Townsend, 1980). The mismatch of schema and the schema shift produce difficulties in comprehension.

It seems clear that appropriate schema should be activated in order to prodece the best learning results. This can be done in a number of ways in the instructional process or built into the instructional materials designed and developed. We will return to this later.

ASSESSING LEARNER'S PRE-EXISTING SCHEMATA

The learners' pre-existing schemata and the activation of them are so critical in learning, as briefly described previously, that the instructional designers have to take into account the schemata the target audience already has and the ways to activate these schemata. In order to do so, the instructional designer has to assess the pre-existing schemata prior to designing effective instruction.

The assessment may not be a formal measurement in lots of times. A designer may have been working with a specific student population for a long time, and he or she has some clear idea about his target audience's prior knowledge (schemata). Sometimes, the designer may estimate the learners' schemata by analyzing their general backgound such as cultural heritage and their native language, and appropriate activities can be arranged to help activate students' pre-existing schemata prior to or during learning.

However, to assess the learners' existing schemata, the best way is to have the students demonstrate how much and how well they know about a particular topic. In this aspect, not many systematic ways have been developed. Langer (1980, 1984) designed and tried out an approach to measure learners' prior knowledge.

According to Langer (1980), a learner's prior knowledge could have three different levels. The lowest level is called Diffused Organized Knowledge. At this level, the learners can only report personal experience or tangential cognitive links. The second level is Partially Organized Knowledge. At this level, the learner can provide examples of a concept and define it in terms of its main characteristics. The highest level of prior knowledge is called Highly Organized Knowledge. Learners at this level can elaborate the concept provided to its superordinate and related concepts and define the concept precisely. Langer (1981,1984) and others (e.g., Hare, 1982) used and validated this measure in predicting students' comprehension and recall.

Applied in our instructional design process, the designer may need to identify and describe the learners' pre-existing schemata following the structure suggested by Langer in the learner analysis stage, and in the design/development stage, build in instructional treatments addressed to the audience differently but corresponding with the three levels of prior knowledge. For example, if the learners' prior knowledge is at a lower and diffused level, their schemata may be too weak to be sufficient for new learning. More backgound information should be provided to help students comprehend the new information. If the learners' schemata are at the highest level, cues such as proper titles and/or illustrations would be enough to help students connect the new learning with their existing schemata.

ACTIVATING STUDENT EXISTING SCHEMATA

Knowing the status of the learners' schemata is not enough to develop effective instruction. The learners' schemata have to be activated and connected to the new learning in order to have positive instructional results as described previously. Schema activation can play a great role in this the information process through guiding learners to select, abstract, interpret, and integrate incoming information (Alba & Hasher, 1983). Though no systematic strategy has been developed to activate students' schemata, various techniques have been tried by the researchers and field instructors.

Pre-treatment activities. One way to activate learners' existing schemata is, prior to instruction, to engage the learners in thinking about their existing, related schemata and in relating them to the new learning. Langer (1984) describes her program of pre-learning activities called PREP (Pre Reading Plan). In PREP, teachers select key words or phrases (superordinated concepts from the target passages) that are central to the understanding of the passage and try to engage students to review what they already know about the target topic. This program consists of three phases:

(1) Initial associations with the concept selected -- "Tell me anything that comes to mind when ...."

(2) Reflections on initial associations -- "What made you think of ..."

(3) Reformation of knowledge -- "Based on our discussion, have you had any new ideas about ... "

Through this method, the learners' whole schemata at various levels could be activated systematically. Based on this program, Melendez and Pritchard (1985) developed a set of three questions to guide foreign language students to relate the target reading text to their native culture and language, and produced positive results. Langer (1984) reported that because the pre-reading activity significantly raised the available prior knowledge, it significantly improved student comprehension of moderately difficult passages.

Another pre-instructional treatment was developed by Cunningham (1984). In Cunningham's program called schema-access/purpose setting, the teacher provides students, prior to reading, with a set of questions in a workbook format that would remind students of what they have known or experienced about a topic and that simultaneously would help students to discover something they did not know or were unaware of about the topic. For example, to the topic, "Moving to a new school", several questions can be asked in a workbook such as: Have you ever moved to a new school? Who do you know who moved to a new school? What might some advantages of moving be? What might some problems be? These questions can help students recall their experience about moving or imagine what would happen to a moved students. As a result, the learners' previously acquired knowledge and experience are activated and used in the new learning.

Text enhancement (Gagne, 1986). Another way to help activate students' pre-existing schemata is to provide cues in learning materials or instructional process. Gagne discusses a number of ways of enhancing text display of computer-based instruction including insertions, verbal elaborations, text variations and mapping. Using these techniques, the "slots" of a schema represented by the learning material are highlighted, or students' pre-existing knowledge is directly drawn to elaborate new concepts.

Other researchers have used various cues in reading materials to help activate student prior knowledge. Contextual information (e.g., Norman, Gentner & Stevens, 1976; Schallert, 1976; Townsend, 1980) has been found valuable in helping students form a mind set toward the topic to be learned, that is, to help the students form an expectation of the type of incoming information and readily process the information in the intented way. Several methods can be used to accomplish this. One is to provide a set of pre-passage questions asking the students about the context of the reading materials. Another one would be to give the reading material an apropriate title which indicates the context of the material to be read. One important way is to incorporate students' existing schemata itno the instructional process so that the materials are close to their experiences and knowledge. For example, in the instructional materials or classroom teaching practice, examples familiar to the students should be used to elaborate concepts rather than using unfamiliar context (Ross, 1983).

Metaschemata. Student knowledge about their own schemata related to a particular topic may be very important. Little is known regarding metaschemata, but a number of researchers have suggested that students learn the ways to evaluate their own schemata and to modify them as necessary (e.g., Gagne & Dick, 1983; Norman, Gentner & Stevens, 1976).

In summary, schema is a critical factor that should be considered in the instructional design process. To a large extent, the pre-existing schema related to a particular learning topic influence learners' processing and retention of new information. Instructional designers should systematically assess their target audience's pre-existing schemata and activate them in order to produce efficient and effective learning. To approach this, various strategies available can be applied prior to instruction, during instruction and in the materials designed and developed. Furthermore, the activation mechanics should be addressed to appropriate schemata so as to result in the best learning results.

References

Alba, J., & Hasher, L. (1983). Is memory schematic? *Psychological Bulletin*, *93*, 203-231.

Anderson, O. S., & Acker, R. L. (1984, December). Investigation of the effects of prior knowledge on comprehension of discourse by good and poor comprehenders. *Reading World*, pp. 87-95.

Anderson, R. C., Pichert, J. W., & Shirey, L. L. (1983). Effects of the reader's schema at different points in time. *Journal of Educational Psychology*, *75*, 271-279.

Anderson, R. C., Reynolds, R. E., Schallert, D. L., & Goetz, E. T. (1977). Frameworks for comprehending discourse. *American Educational Research Journal*, *14*, 367-381.

Avron, H. (1985). The influence of background knowledge on nonnative students' memory forreading passages (Doctoral dissertation, Rutgers University the State University of New Jersey, 1984). *Dissertation Abstracts Interantional*, *46*, 386A.

Bartlett, F. C. (1932). *Remembering*. Cambridge: The Cambridge Univeristy Press.

Bransford, J. D., & Johnson, M. K. (1972). Contextual prerequisites for understanding: Some investigations of comprehension and recall. *Journal of Verbal Learning and Verbal Behavior*, *11*, 717-726.

Brewer, W., & Nakamura, G. (1984). The nature and functions of schemas. In R. Wyer & J. Srull, (Eds.), *Handbook of social cognition*. Hillsdale, NJ: Erlbaum.

Chi, M. H. (1978). Knowledge structures and memory development. In R. S. Siegler (Ed.). *Children's thinking: What develops?* Hillsdale, NJ: Erlbaum.

Chiesi, H. L., Spilich, G. J., & Voss, J. F. (1979). Acquisition of domain-related information in relation to high and low domain knowledge. *Journal of Verbal Learning and Verbal behavior,* *18*, 257-274.

Cunningham, P. (1984). What would make workbooks worthwhile? In R. C. Anderson, J. Osborn, & R. J. Tierney (Eds.), *Learning to read in American schools*. Hillsdale, N.J.: Erlbaum.

Gagne, R. (1977). Schooling and the relevance of research: General discussion of the conference. In R.

C. Anderson, R. J. Spiro & W. E. Montague (Eds.) *Schooling and the acquisition of knowledge*. Hillsdale, N. J.: Erlbaum.

Gagné, R. (1986). Instructional technology: The research field. *Journal of Instructional Development*, *8*(3), 7-14.

Gagné, R., & Dick, W. (1983). Instructional psychology. *Annual Review of Psychology*, *34*, 261-295.

Graesser, A. & Nakamura, G. (1982). The impact of a schema on comprehension and memory. In G. Bower (Ed.), *The psychology of learning and motivation: vol. 16*. New York, NY: Academic Press.

Hare, V. C. (1982) Preassessment of topical knowledge: A validation and an extension. *Journal of Reading Behavior*, *14*(1), 77-85.

Kozminsky, E. (1977). Altering comprehension: The effect of biasing titles on text comprehension. *Memory & Cognition*, *5*, 482-490.

Langer, J. A. (1980). Relations between levels of prior knowledge and the organization of recall. In M. L. Kamil & A. J. Moe (Eds.), *Perspectives in reading research and instruction*. Washington, DC: National Reading Conference.

Langer, J. A. (1981). From the theory to pracatice: A prereading plan. *Journal of Reading*, *25*(2), 152-156.

Langer, J. A. (1984). Examining background knowledge and text comprehension. *Reading Research Quarterly*, *14*, 468-479.

Melendez, E. & Pitchard, R. (1985). Applying schema theory to foreign language reading. *Foreign Language Annual*, *18*,399-403.

Norman, D., Gentner, D., & Stevens, A. (1976). Comments on learning schemata and memory representation. In D. Klahr (Ed.), *Cognition and memory*, pp. 177-196. Hillsdale, NJ: Erlbaum.

Ross, S. M. (1983). Increasing the meaningfulness of quantative material by adapting context to student background. *Journal of Educational Psychology*, *75*, 519-529.

Royer, J. M., & Canle, G. W. (1975). Facilitative transfer in prose learning. *Journal of Educational Psychology*, *67*, 116-123.

Royer, J. M., & Cable, G. W. (1976). Illustrations, analogies, and facilitative transfer in prose learning. Journal of Educational Psychology, 68, 205-209.

Schallert, D. L. (1976). Improving memory for prose: The relationship between depth of processing and context. Journal of Verbal Learning and Verbal Behavior, 15, 621-632.

Spilich, G. J., Vesonder, G. T., Chiesi, H. L., & Voss, J. F. (1979). Text processing of domain-related information for individuals with high and lowdomain knowledge. Journal of Verbal Learning and Verbal Behavor, 18, 275-290.

Steffensen, M. S., Joag-dev, C., & Anderson, R. C. (1979). A cross cultural perspective on reading comprehension. Reading Research Quarterly, 15, 10-29.

Townsend, M. (1980). Schema activation in memory for prose. Journal of Reading, 12(1), 51-53.

Tyler, S. W. & Voss, J. F. (1982). Attitude and knowledge effects in prose processing. Journal of Verbal Learning and Verbal Behavior, 21, 524-538.

Wilhite, S. C. (1983). Prepassage questions: The influence of structural importance. Journal of Educational Psychology, 75, 234-244.

The Effect of Stories and Diagrams on Solution of an Analogous Problem

Carla Mathison
Brockenbrough S. Allen
Department of Educational Technology
San Diego State University
San Diego, CA 92182-0311

The Effect of Stories and Diagrams on Solution of an Analogous Problem

Carla Mathison and Brockenbrough S. Allen
Department of Educational Technology
San Diego State University

Reasoning by analogy pervades everyday living and learning. We draw on past experiences to help us understand new situations. Counseling a friend, we think of how we felt in a similar situation. Deciding on which dishwasher to buy, we consider criteria used for other household appliance purchases. We transfer our knowledge about how to solve a particular geometry problem to a new setting involving architectural design. We examine the industrial revolution for clues about the future of on our own revolution in communications. As Oppenheimer noted, "analogy is inevitable in human thought" (1956, p. 129).

Background

Analogical reasoning is not necessarily spontaneous. Recognizing and applying past experience and knowledge to new situations involves a complex set of cognitive processes that include abstraction, subsumption, and domain integration. There is strong support for the effectiveness of formal training in deeper levels of analogical processing (Dreistadt, 1969; Gabel & Sherwood, 1980; Jorgenson, 1980; Reigeluth, 1983; Royer & Cable, 1976; Schustack & Anderson, 1979; Winn, 1982). Interest in analogical transfer in problem-solving activity goes as far back as Esher, Raven & Earl (1942). More recent work includes Hayes & Simon (1977); Reed, Ernst & Banerji, (1971); Rumelhart & Abrahamson (1973); and Sternberg (1977a, 1977b).

Gentner (1983) proposes "structure-mapping" as technique for understanding analogies. She distinguishes analogies from other types of comparisons, defining an analogy as " . . .a comparison in which relational predicates, but few or no object attributes can be mapped from base [the familiar] to target [the new]" (p. 159). The strength of a specific structural relationship is determined by the number and degree of smaller, interconnecting relationships which it subsumes. Gentner also uses structure mapping to describe the fundamental elements of simple analogical reasoning. The process depends on three basic mapping "rules": 1.) Discard attributes of objects; 2.) Try to preserve relations between objects. 3.) Decide which relations are preserved; choose system of relations (Systematicity Principle).

Effect of Prior Knowledge on New, Analogous Problems

Gick and Holyoak (1983) investigated the factors that underlie spontaneous recognition of analogies between prior knowledge/experience and new problem situations. They were particularly concerned with what they term semantically disparate problems—situations in which prior knowledge has few surface similarities with the new situation.

Gick and Holyoak have found that learners are more likely to recognize prior knowledge and experiences as relevant to a new problem if they have acquired a schema that is more abstract or more general than the several individual experiences that are each relevant to the problem. The assumption is that exposure to two or more analogous situations induces a "convergent" schema by encouraging the learner to "map" the analogs and abstract the similarities in fundamental structure.

Unresolved Issues

A close examination of Gick and Holyoak's methodology in experiment 4 (1983) raises several issues. Gick and Holyoak found that when learners were given two analogies prior to a new problem they were much more likely to spontaneously recognize and apply prior knowledge than when they were given only one analogy. However, the conditions under which these two groups initially learned their respective analogies were very different.

Subjects in the two-analogy group were given two analogous stories involving problem-solving and were asked to: 1.) read each story, 2.) summarize it, 3.) rate its comprehensibility, and finally, 4.) describe, in writing, the similarities between the two stories. Immediately following this last activity, subjects were given the new problem and asked to solve it. Subjects in the one-analogy group were given one story that was analogous to the new problem and one disanalogous story. The subjects were then asked to perform the same four activities and to solve the new problem.

Consider Step 4, in which learners were asked to "map" similarities between the two stories. Gick and Holyoak hypothesized that instructions to find similarities would encourage subjects in the two-analogy group to identify and abstract relationships relevant to the new problem. However, this instruction may have had an unintentional and opposite effect on the one-analogy group. Struggling to find similarities between two disanalogous stories may have led these subjects to distort their representation of the relationships in the analogous story to such an extent that they were then unable to recognize its similarities to the new problem.

Research Questions

Is it possible that, under different circumstances, exposure to a single analog prior to the problem-solving task could yield more favorable results? This question is important for what it implies about the cognitive processes involved in analogical reasoning and for what it suggests about how to use instructional techniques to promote these processes. Must learners encounter multiple analogs in order to develop a general schema that can be transferred to future problems? Or, is a single analog sufficient assuming that learners are helped to identify fundamental structural relationships. The hypothesis for the current study assumed that subjects who received a diagram representing the structural relationships of the story would be more likely to solve a new and analogous problem than subjects who received two analogs without a diagram.

Experiment Design

The subjects were 151 post-baccalaurate students enrolled in a fifth-year teacher education program. The experiment employed a 2 X 2 factorial design: The first independent variable was the number of story analogs; the second independent variable was the type of instruction accompanying the story analogs (diagram vs. no diagram). The dependent variable was performance on a new problem-solving task.

Story Analogs. These stories were adapted from those used by Gick and Holyoak. Each story described a goal, resources, constraints, and a solution. One story told about neighbors who put out a fire by encircling it and dousing it with small buckets of water. The other described how an army faced with narrow roads then attacked a fortress in small groups from many directions at once. The basic principle underlying both stories was as follows:

> sometimes, when it is impossible to attack a target with a large force from one direction, it may be better to disperse forces and attack from many directions simultaneously.

This principle is the only one which yields a satisfactory solution to the analogous problem used for the outcome measure. Students were asked how they would use "laser" rays to destroy a malignant stomach tumor . They were told that one high-intensity laser beam would destroy the tumor but would also destroy intervening tissue. They were also told that low-intensity beams are harmless to healthy tissue. No hint was given to as to the analogous relationship between the stories and the new problem.

Diagrammatic Representation. The diagram--also adapted from Gick and Holyoak--represented this principle in visual form accompanied by a text statement of the principle (see figure 1). Learners were asked to copy the diagram in a provided space and then asked to read the story analog.

The most important changes in the original Gick and Holyoak stories involved the insertion of a cue that asked subjects to think about the diagram as they read the story. (Subjects who did not receive the diagram did not receive this cue.)

Learners who did not receive the diagram were asked to rate the stories in terms of ease of understanding. Learners who did receive the diagram were asked to rate the diagram's usefulness in explaining the problem encountered in the stories. All learners were then given the new problem and asked to solve it.

Procedures

Treatments were administered in booklet form to six intact college classes. A table of random numbers was used to assign booklets to subjects. Subjects were instructed orally to proceed through the booklet in a linear fashion and to read written instructions carefully. Booklets were collected 30 minutes later.

Analysis of Data

Learners' solutions to the new problem were judged by two independent readers as either correct or incorrect. To be judged correct, a solution had to include a 'dispersion' strategy similar to that found in the story analogs. That is, it had to include a reference to simultaneous application of smaller forces from multiple directions.

Results

Scores were converted into percentages and submitted to a chi square analysis. Table 1 shows the percentage of correct solutions across all treatment groups.

Percentage (Numbers) of Correct Solutions
Across All Treatment Groups

	WITHOUT Diagram	WITH Diagram
One-Story Analog	5.1% (2) N=39	61.1% (22) N=36
Two-Story Analogs	13.5% (5) N=37	69.2% (27) N=39

TABLE 1

Of the 151 subjects, 36% (55) produced the correct solution to the problem. The effect of the number of story analogs on solution production was estimated by comparing the scores of students who received one story analog with the scores of students who received two analogs (see Table 2) This comparison revealed no significant difference.

Percentage (Number) of Correct Solutions For Subjects
Receiving One and Two Story Analogs

	One Analog	Two Analogs
Correct Solutions	42% (24)	57.2% (32)

TABLE 2

Table 3 presents an analysis of the effect of the diagram on the solution rate. Of the subjects receiving the diagram, 65% were able to solve the new problem compared to only 9% of those who received no diagram. This distribution was significant at the .01 level.

Percentage of Correct Solutions

	WITH Diagram	WITHOUT Diagram
Correct Solutions	65.3% (49)	9.2% (7)

TABLE 3

The results support the hypotheses of this study. The data indicate that the number of story analogs received by subjects had no effect on in their success in solving an analogous problem. Interaction with a diagrammatic representation, however, greatly facilitated the transfer of solutions to the analogous problem.

Discussion

This study does not necessarily argue against multiple analogies as a means for promoting convergent schema nor does it argue against multiple analogies as a tool for promoting analogical transfer. Gick, Holyoak, and others provides substantial evidence that exposure to multiple analogs can lead to such schema building. However, learners in the treatment group that was most successful in the Gick and Holyoak (1983) study received more than a mere presentation of story analogs: they were directed to interact with the stories—asked to write down the similarities between the two problem situations.

In the present study, the focus of activity was on interaction with the diagram (copying it) and on interaction with the diagram and the analogous stories (cues to think about the relationship between the diagram and stories; requests to rate the usefulness of the diagram in explaining the problem in the story). The findings suggest that processing activity and orienting messages may are at least as important as a means for inducing convergent schema and promoting analogical processing as is the number of analogs. In the present study, when learners were given two stories but no direction to interact with the text or diagram, they had little success in solving the new problem. This finding suggest that, although multiple similar problem-solving experiences may help learners solve new problems analogically, the key variable is not the number of experiences but the manner in which they are presented and processed.

REFERENCES AND BIBLIOGRAPHY

Anderson, J. R. (1976). Language, memory, and thought. Lawrence Erlbaum Associates, Hillsdale, N. J.

Anderson, R. C. & Pichert, J. W. (1978). Recall of previously unrecallable information following a shift in perspective. Journal of Verbal Learning and Verbal Behavior, 17, 1-12.

Carbonell, J. G. (1983). Learning by analogy: Formulating and generalizing plans from past experience. In R. S. Micalski, J. G. Carbonell, & T. M. Mitchell (Eds.), Machine Learning: An artificial intelligence approach, (pp. 137-59), Palo Alto, California: Tioga Publishing Company.

Gentner, D. (1983). Structure-mapping: Atheoretical framework for analogy. Cognitive Science, 7, 155-70.

Gick, M. L. & Holyoak, K. J. (1980). Analogical problem solving. Cognitive Psychology, 12, 306-55.

Gick, M. L. & Holyoak, K. J. (1983). Schema induction and analogical transfer. Cognitive Psychology, 15, 1-38.

Hayes, D. A. & Mateja, J. A. (April, 1981). Long term transfer effect of metaphoric allusion. Paper presented at the Annual Meeting of the American Educational Research Association, Los Angeles, Ca.

Jensen, J. V. (1975). Metaphorical constructs for the problem-solving process. Journal of Creative Behavior, 9, 113-24.

Jorgenson, S. (1980). Using analogies to develop conceptual abilities. Paper presented at Annual Meeting of the Association for Educational Communications and Technology, (EDRS Document Reproduction Service No. ED192820), Denver, Co.

Oppenheimer, J. R. (1956). Analogy in science, American Psychologist, 12, 127-35.

Petrie, H. G. (1979). Metaphor and Learning. In A. Ortony, Metaphor and thought. Cambridge: Cambridge University Press.

Reed, S. K., Ernst, G. W., & Banerji, R. (1974). The role of analogy in transfer between similar problem states. Cognitive Psychology, 6, 236-50.

Roediger III, H. L. (1980). Memory metaphors in cognitive psychology. Memory & Cognition, 8, 231-46.

Royer, J. M. (1979). Theories of the transfer of learning. Educational Psychologist, 14, 53-69.

Royer, J. M. & Cable, G. W. (1976). Illustrations, analogies, facilitative transfer in prose learning. Journal of Educational Psychology, 68, 205-09.

Rumelhart, D. E. & Abrahamson, A. A. (1973). A model for analogical resoning. Cognitive Psychology, 5, 1-28.

Rumelhart, D. E. & Ortony, A. (1977). The representation of knowledge in memory. In R. C. Anderson, R. J. Spiro, & W. E. Montague (eds.), Schooling and the acquisition of knowledge. Hillsdale, N. J.: Erlbaum Associates.

Rumelhart, D. E. (January, 1981). Understanding understanding. University of California, San Diego: Center for Human Processing, (Report No. 8101).

Rumelhart, D. E. & Norman, D. A. (1981). Analogical processes in learning. In J. R. Anderson, (Ed.), Cognitive skills and their acquisition. Hillsdale, N. J.: Erlbaum Associates.

Schustack, M. W. & Anderson, J. R. (1979). Effects of analogy to prior knowledge on memory for new information. Journal of Verbal Learning and Verbal Behavior, 18, 181-201.

Simon, H. A. (1978). Information-processing theory of human problem solving. In W. K. Estes (Ed.), Handbook of learning and cognitive processes. Hillsdale, N. J.: Erlbaum Associates.

Sternberg, R. (1977a). Component processess in analogical reasoning. Psychological Review, 84, 353-79.

Sternberg, R. (1977b). Intelligence, information processing, and analogical reasoning: The componential analysis of human abilities. Hillsdale, N. J.: Erlbaum Associates.

Tourangeau, R. & Sternberg, R. (1981). Aptness in metaphor. Cognitive Psychology, 13, 27-55.

Tversky, A. (1977). Features of similarity. Psychological Review, 84, 327-50.

Winston, P. H. (1970). Learning structural descriptions from examples. (Rpt. AITR-231), Cambridge, Mass.: MIT, Artificial Intelligence Laboratory.

COMPREHENSION AND RECALL OF TELEVISION'S COMPUTERIZED IMAGE:
AN EXPLORATORY STUDY

by

Nikos Metallinos, Ph.D.

Associate Professor of Communication Studies

and

Sylvie Chartrand

M.A. Candidate in Media Studies

Concordia University

Department of Communication Studies

7141 Sherbrooke Street West

Montreal, Quebec H4B 1R6

482 452

COMPREHENSION AND RECALL OF TELEVISION'S COMPUTERIZED IMAGES:
AN EXPLORATORY STUDY

483453

Abstract

Our constant exposure to digital television pictures, video game imagery and computerized graphic effects has affected our visual perception process. Since our ability to comprehend and retain images depends on the way they are structured and presented in visual space, the shape of these images, their direction within the visual space, and the speed at which they move are some of the key factors relative to their retention and understanding. In this study, (1) the empirical findings of the composition of such images are reviewed, (2) their potential effects on heavy viewers are underlined, (3) the most suitable research instruments for their study are discussed, and (4) the results of a pilot study in which biometric research instruments were used to test the effects of computerized television pictures on viewer comprehension and retention are discussed. Since this is an exploratory study with a threefold purpose of (1) providing the theoretical framework for the research, (2) introducing the appropriate research instruments for the study, and (3) experimenting with the application of biometric instruments in testing the effects of computerized television pictures, scientific conclusions cannot be drawn. It is suggested however, that since new technologies produce unanticipated and covert perceptual effects in visual space composition, technologically more advanced and more suitable research instruments need to be employed for the study of such hidden effects. Finally, such key factors as shape, direction, and motion of objects appearing within the visual space are crucial to the study of viewer comprehension and retention of computerized visual images.

COMPREHENSION AND RECALL OF TELEVISION'S COMPUTERIZED IMAGES:

AN EXPLORATORY STUDY

The new visual communication media imagery such as video games, digital television, and computerized pictures are capturing the attention of viewers of all ages and causing a real revolution in imagery while stressing contemporary man's ability to fully perceive and accurately recall visual information to its fullest extent. Some of the consequences of this boom in computerized video imagery are obvious, and some of their characteristics are easily identifiable. But many more remain hidden.

A noticeable cause of this revolution is the instant acceptance of visual display and images. Prior to the invention of computerized graphic designs, video game imagery, and digital television effects, the length of time required to digest and comprehend visuals after perceiving them was fairly noticeable. Today heavy users of these new visual communication media can instantly read, evaluate, and recall them, as can be attested by watching young people in any video arcade.

Another cause of the rapid growth of the new media imagery is the nature of their visual elements. The elements used to fill in the visual space are no longer those of everyday life in the real world. These new elements are small squares, plastic boxes, contours of the actual images. They all provide a novelty which attracts people. People unquestionably accept them and easily adopt them, never challenging their aesthetic value.

An additional cause of people's fascination with the new media technology is the constant utilization of depth axis staging. The visual elements that comprise the image are often placed within the Z-axis, moving rapidly towards or away from the viewer, often vanishing from the screen or blasting towards the viewer unexpectedly. Sometimes, entire frames fly away, flip over, or retreat towards the vanishing point.

This instantaneous acceptance of digital TV pictures, video game images, and computerized graphic designs might not show any serious effects at a glance, but as Kuipers (1983, p. 27) points out, such effects do exist. They are multidimensional and the most common ones are physical and psychological.

These unreal cartoon type images could be one of the reasons young people are being driven further and further away from the reality of the physical world (Gardner, 1984). It might be that such images are affecting their basic understanding of the dichotomy between the visual world and the visual field, and the unique properties assigned to each of them (Gibson, 1950, p. 164).

The emphasis and persistance in the use of depth composition and extraordinary special effects, coupled with the unusually fast advance and retreat of visual space, have been found to have some negative effects on viewer comprehension and understanding of visual space (De Long, 1983), the most serious of which is viewing fatigue (Levy, 1983, p. 6).

In order to be able to isolate and examine such specific effects, the following four questions were raised:

1. In the area of film and television composition, which research studies deal specifically with picture depth?
2. What are the specific effects which influence viewers' perception of visual space as it relates to television Z-axis staging?

3. Given that the above effects could be readily identified and controlled, what are the most suitable research measuring devices for their systematic verification and study?
4. Do the factors of shape, direction, and motion of computerized TV images influence viewer comprehension and recall of such images?

Visual Space: Composition of the Depth Axis

The term visual space, in this study, refers to the opening of the two dimensional surface of a regular TV screen surrounded by the borders of the TV set. It is often referred to as "the concentrated living space, a new field of aesthetic expression" (Zettl, 1973, p. 100). It is the field in which constructors of visual images compose pictures by controlling the various forces generated by visual elements operating within its borders (Metallinos, 1979, p. 206). Due to its small size and its condensed visual field, television picture constructors have tried to gain in depth that which they lose in horizontal framing. The small vista of the TV screen necessitates the practice of favoring the placement of visual elements on the depth axis rather than the horizontal one. This is known as the television Z-axis staging technique (Zettl, 1973, p. 175).

Numerous scientific studies dealing with the placement of visual elements within the depth variable in motionless visual space is given by Arnheim in his book Art and Visual Perception (1969). In film, the most prominent of such studies are Deregowski's examination of depth cues and pictorial perception of people from different countries (1972, 1971) and Evans and Seddon's investigation of the perception depth cues among Nigeria students

(1978).

Empirical research examining the potential perceptual and physiological effects of the Z-axis staging technique in television are non-existant. Research studies that would verify the Z-axis staging theory and underline its advantages and limitations are limited. Various constructs which identify the theory have been underlined by Millerson (1972), Zettl (1973), Malik (1976), Dondis (1973), and others.

A major construct of TV Z-axis staging is movement towards or away from the foreground of the visual space. Millerson discusses this construct in terms of viewer interest in movement of the camera and contends that:

> Movement towards the camera being more striking that movement away from it, we find that any forward gesture or movement is more powerful than a recessive action (i.e. a glance, a turned head, a pointed hand). A shot approaching a subject arouses greater interest than one withdrawing from it . . . (1968, p. 290).

Zettl asserts that motion along the Z-axis can be one of the most powerful indicators of depth in the two dimensional field of the TV screen (1973, p. 192). He recognizes the visual impact generated by the combined motions of the camera moving towards or away from the foreground, zooming in or zooming out, and movement of the object or subject (1973, p. 194). Anticipating users' abusement of such a technique, Zettl warned us that if the zoom-in and zoom-out on the Z-axis is fast enough, it gives the impression that the objects or people either crash through the screen, right towards the viewer, or crash into something beyond the horizon away from the viewer

(1973, p. 194).

Malik recognizes three types of movements within the video image which he calls "movement of the electron beam," "movement of the camera," and "inner movement" (1978, p. 11). He emphasizes that abusement and mishandling of any such movements while on the Z-axis will have negative effects on the viewer and warns us that "if several domains within the picture are moved simultaneously, the possibility of information delivery diminishes arithmetically" (1978, p. 11).

Another major construct of TV Z-axis staging is the depth of field, which increases or decreases with the use of the wide or narrow angle lense or the telephoto or normal zoom lense. Recognizing the flexibility offered by the manipulation of the depth field in television composition, Millerson states that " deep focus techniques may help to achieve an illusion of spaciousness and depth, when scenic planes stretch from foreground into the distance" (1972, p. 225).

Zettl, in discussing the depth characteristics of lenses as they relate to the depth of field in television pictures, explains that such depth cues as "overlapping planes," "relative size," "height in plane," "linear perspective," and "aerial perspective" shrink space and make objects appear closer together than they really are when they are paired with the wide angle lense (1973, p. 190).

A third construct of the television Z-axis staging theory is direction within the visual space created by objects and people placed in succeeding lines, one after another, or by vectors leading the viewer's eyes towards the center of the screen, or by people and objects moving towards or away from the foreground. Zettl discusses this variable in television composition in terms of blocking on the Z-axis vector which is defined as the visual line (action line) created by the placement or blocking of objects and people on the vertical plane within the X and Y axis (1973, p. 214). Although Zettl has stressed the power exerted by such direction indicators when blocking the Z-axis, empirical research which precisely measures and verifies its power and effectiveness is non existant.

In fact, none of the constructs or variables mentioned above have been empirically verified by communication researchers. It is speculated that the delay in dealing with these variables could be detrimental to the study of television composition and the development of the field of television aesthetics.

Visual Space: Psychophysiological Effects of the New Imagery

The imagery explosion created by the new technology in visual communication media, has had its effects on multiple levels (psychological, physiological, neurological, sociological, etc.) and has generated a plethora of literary sources on their impact upon users of these media. Herein, the psychophysiological effects that these media exert on heavy users will be underlined insofar as they relate to the constructs of "movement," "depth of field," and "direction" in the theory of television Z-axis staging.

Rapid Inward-Outward Movement

Perceptual psychologists have pointed out that rapid inward and outward movement of visual elements in the visual field decrease the viewer's ability to receive, process, and recall detailed information (Miller, 1968). The span of time required to make a judgement about the structure of perceived visual image is analogous to the speed at which such images move in and out of the visual space.

The problems pertinent to the perception of motion and the limitations imposed by our eidetic apparatus have been examined by such psychologists as Spigel (1968), who underlines the overall problems of visually perceived movements, Kolers (1968), who discusses the differences between real and apparent visual movements, Macworth (1968), who examines visual acuity when the eyes are perceiving moving targets, Treisman (1968), who has studied the elements producing visual attention in the confined visual space, Averback (1968), who has measured the span of apprehension as a function of exposure duration, and others. What these and similar studies confirm is that neurophysiologically speaking, man's ability to receive (see), process (recognize), and recall (remember) visual information in motion is limited. Furthermore, viewer's ability to instantaneoulsy perceive and comprehend images moving rapidly towards or away from the foreground of the visual space depends greatly on several external and internal parameters which must be correlated and controlled. Externally, the shapes, sizes, and structures of objects in the environment must be perceived, and internally, the total synthesis of such images must be comprehended.

An unusually accelerated motion of images placed within the Z-axis line is perceived as unnatural and unbalancing, contrasting the viewer's apprehension against his/her's appreciation of the synthesis of the images. Let us consider, for example, what happens during an airplane chase as presented by video game imagery when placed along the Z-axis line. A barrage of planes (levels on which the various reference points of the field are placed) and various objects surrounding these planes move rapidly towards or away the viewer, leaving no noticeable trace as to their structures, shapes, colors, or synthesis. These structures, moving so rapidly, do not produce any perceptual excitement and/or aesthetic feeling other than the anticipated immediate collision and explosion. Persistant viewers of these images and actions do not have the chance (due to the split-second span of time required between perception and cognition) to comprehend the messages, let alone to appreciate them. This causes "perceptual and emotional numbing" (Edmundson, 1984, p. 52) in heavy users of video games and viewers of constant special effects in television images.

Distorted Depth of Field

Painters, photographers, and filmmakers have always recognized the need to create the illusion of depth in the visual space. They have employed such techniques as "overlapping planes," "relative size," "height in plane," "linear perspective," "aerial perspective" (Zettl, 1973), "tonal manipulation of the light and shade of pictures" (Dondis, 1973), etc. Filmmakers and photographers were also able to make use of different lenses to create depth such as (a) the wide angle lenses to produce a long, narrow depth of field, (b) the narrow angle lense to produce a short, wide depth of field, and (c) the normal lense. The invention of the moving camera gradually changed these fixed focal length lenses into zoom and telephoto lenses which have the capacity to enormously exaggerate or diminish the depth of field. Without doubt, the limitations posed by the fixed focal length lenses of the past have been greatly eliminated by this new technology. However, the abuse of such technology has caused considerable concern among constructors of visual images.

Some theorists have warned us that distorted depth of field caused by the combined application of depth cues and extreme variance in focal length produces forced and unnatural perspective (Zettl, 1973, p. 190). It shrinks space, or as Dondis puts it, collapses "space like an accordion" (1973, p. 61). The technology has ignored and overlooked subtle principles of visual perception and neurophysiological limitations. The depth of field in a picture is the reference point, the establishing shot, the home base, which viewers use to observe, to perceive, and to comprehend representations of the real world. When such fields rapidly and unexpectedly shrink or expand, shifting the convergence in depth perspective and destabilizing the observer's point of view, a considerable break-down in the viewer's ability to distinguish optical reality from perceptual reality is caused (Kolers, 1968).

Forceful Direction of Z-Axis Vectors

Visual researchers have underlined the visual strength, power, and dynamism exerted by directional lines found in the Z-axis vectors (Zettl, 1973, Dondis, 1973, Taylor, 1964, Averback, 1968). The dangers, along with the particular psychophysiological effects of directional lines caused by blocking in the Z-axis vectors were underlined and studied by Gregory (1968), who pointed out the distortion of visual space caused by inappropriate consistancy scaling, Beck (1968) who examined the changes in shape and orientation when elements are in vertical axis and Macworth (1968), who found that excessive and complex visual stimulus on the Z-axis line produces a visible noise known as "tunnel vision."

When television images represent the real world on the vertical axis of the visual field, they enhance the perception of depth because of forced directional lines which are created by the blocking of visual elements. One such effect is known to perceptual psychologists as "convergence error" (McKim, 1980, p. 81), a principle which states that the directional lines in the depth axis cause image distortion and viewer discomfort. To correct such effects, McKim suggests that:

> A rule of thumb for the freehand visualizer is that vanishing points for small objects should be located far apart relative to the size of the image, and vanishing points for large objects (such as buildings) should be located relatively close together (1980, p. 82).

Another effect caused by strong directional lines and forceful vectors is referred to as a "reinforced or focusing perspective" (Arnheim, 1969, p. 284). Strong directional indicators on the Z-axis vector forces our visual attention on certain objects at the expense of other objects in the field which remain totally unnoticeable. Recognizing how powerful such a force is as a means of representation and expression, Arnheim warns that "focusing produces a powerful dynamic effect. Since the distortions of the receding shapes are compensated only in part, all objects appear compressed in the third dimension" (1969, p. 284).

When we consider the psychophysiological effects caused by rapid inward and outward movement, distorted depth of field, forceful directional lines, and add them all together, one on top of the other, we can understand the degree to which these effects influence heavy viewers and persistant users. The new special effects in visual imagery may be creating what Aynsley describes as "a cinematic alchemy that is stunning and memorable" (1984, p. 6). However, they are often in direct contrast with the basic laws of visual perception and picture composition, overstretching man's ability to comprehend and appreciate them (Levy, 1983).

Visual Space: Research Instruments

The necessity to apply more progressive, diverse, and precise measuring devices to communication media research topics, has been the concern of several communication media scholars such as Behnke (1970), Siebert (1978), Fletcher (1982), Malik (1980), etc. The most appropriate measuring devices for the study of visual images have been found to be the psychophysiological measuring instruments developed in the fields of neurophysiology and psychology (both visual and experimental).

In this section, the major and most commonly used psychophysiological research instruments will be briefly discussed in connection with their application to the depth axis variables in visual images.

Psychophysiological measuring techniques concern themselves with the covert or hidden responses to communication stimuli such as detection of eye movements, dilation of the pupils, increase in brain activity, changes in heart rate, variations in skin resistance, changes in pulse, pressure, and frequency, etc. These covert responses are accompanied by measurable sensoric reactions or release of energy, which are considered indications in level of activation or state of arousal of the individual. The ultimate purpose of communication media research that utilizes psychophysiological instruments is "to correlate physiological activation levels with various types of behavioral measures" (Behnke, 1970, p. 431).

The various sensoric reactions and energy changes due to information stimulation can be detected, analyzed, quantified, and interpreted by accurate psychophysiological research instruments, all of which operate under a commonly shared measuring system. The psychophysiological devices that measure visual and auditory perception stimuli belong to the category of sensoric reactors. The most commonly used such instruments are:

1. Depth, Size, Motion Apparatus

   These instruments measure various depth effects of phenomena, sizes of visual stimuli (Lafayette Instruments Company, 1980) and numerous illusions of moving or stationary objects (Murch, 1973).

2. Auditory Processors: Audiometers

   These auditory perception measuring devices provide an accurate graphic display of informational input in upper and lower thresholds of frequency and intensity (Lafayette Instruments Company, 1980).

3. Tachitoscopes

   These visual and eidetic devices measure high-speed visual projections of words, forms, and pictures which can also be seen in parts such as left visual field or left eye, and right visual field or right eye (Kimura, 1973).

4. Eye Movement, Eye Dilation, Recording and Monitoring Devices

   These are two types: devices and methods that monitor the various "saccadic" and other eye movements, and those devices and methods that measure the dilation of the eye's pupil. The specific devices used, and the particular methods of measuring the eye movements, are discussed by L. R. Young and D. Sheena (1975) in their survey of eye movement recording methods. The most common eye movement measuring instruments are the Differential Reflection Reading Measuring Device and the Eye-Track. The more up to date devices used for monitoring the pupil dilation are the Monocular and Binocular TV Pupilometer Systems (Koff, Elman, and Wong, 1971, Gulf and Western Research Development Group, 1978).

Psychophysiological instruments measuring energy changes of the body (due to informational stimulation) are divided into five major areas, each of which has generated several devices.

1. Physiological Instruments that Detect and Record Electrical Activity of the Brain

   The most frequently used instruments are the EEG (Electro-Encephalograph) and the BWA (Brain Wave Analyzer). While the EEG detects and measures the various "patterns" and "amount" of brain wave activity of a subject during varied states of stimulation, the BWA detects and identifies the neural efficiency of the subject in terms of learning capacity and learning disability (Ertl, 1975).

2. Physiological Instruments that Detect and Record Skin Resistance or Response

   The GSR (Galvanic Skin Resistance) and the GSP (Galvanic Skin Potential) are the most often used devices in this area. Both are indices of activation level changes in the subjects's exosomatic (external) resistance of the skin (GSR), or endosomatic (internal) resistance of the skin (GSP). Among the communication media related variables detected and recorded by GSR and GSP psychophysiological instruments are: alertness, efficiency, difficulty, information gain, group interaction, emotional impact of words or sounds, etc. (Behnke, 1970, p. 437).

3. Physiological Instruments that Detect and Record Heart Beat Rate

These are instruments that register activation levels in the human circulatory system. The most commonly used heartbeat rate devices are the EKG (Electrocardiograph) which records the electrical activity of the heart muscle, the Sphymograph, which records the arterial pulse contraction, systolic and diastolic (Behnke, 1970, p. 442) and the Stythograph which detects and measures heart rate and consists of an ultra-sensitive microphone, an electrical amplifier, and a counter (Behnke, 1970, Lafayette Instruments Company, 1980). Studies which detect heartbeat rates and which record reactions to specific communication media stimuli, always correlate the findings of these devices with other such psychophysiological instruments.

4. Physiological Instruments that Detect and Record Changes in Muscle Tension

Although there are numerous advance models in existance today, the most frequently used apparatus that detects and measures electrical energy generated by a subject's muscle contraction, is the EMG

(Electromyograph). Whether surface or intramuscular electrodes are used in communication research tests, the high and low amplitude muscle contraction is recorded in relation to the stressful or calm periods of the subject. In media related studies, the findings of muscle tension indicators should be correlated with other such psychophysiological indicators for maximum validity and reliability (Behnke, 1970, Lafayette Instruments Company, 1980).

5. Physiological Instruments that Detect and Record Changes in Volume in Various Parts of the Body

These instruments are also indices of the levels of activation in the circulatory system, and specifically, the automatic nervous system. The devices that detect and record changes in volume in various parts of the body, are collectively called Plethysmographs (PG), from the Greek word "plethos" meaning a great number or enlargement. The commonly used plethysmographs are the Electrical Impedance Plethysmograph (EIPG), the Rheoplethysmograph (RPG), the Girth Plethysmograph (GPG) and the Photo Plethysmograph (PPG) (Brown, 1965). Several communication media oriented variables detected and studied by such plethysmographic instruments which can be found in the literature of visual communication media are: volume intensity, sound appreciation, and quality of performance in verbal tasks. But the variables of motion, depth of field, and direction in TV Z-axis staging have not been studied with these devices at all (Metallinos, 1983).

A number of serious restrictions are imposed on researchers using biometric instruments to measure media-related variables. The signal-to-noise ratio imposed by the instruments themselves is one such restriction. The need to correlate the findings (or graphic output) of one device with the recordings of one or more other devices on the same variable is another. A third restriction is the tendancy of the recorder to overgeneralize on the basis of intricate readings of complex body mechanisms. Fourth, there is the need to perfectly match the initial levels of each subject's biological and physiological activities with those performed during the experimentation period. Finally, there is the need to understand the sensoric, thermal, chemical, and electrical changes of the human body as they relate to both the instrument that records these changes and the conditions under which such recordings occur. However, as Behkne suggests, we should not overlook the application of biometric instruments in communication media research simply because they impose "serious problems and difficulties" (1970, p. 447).

The apparent and hidden psychophysiological effects of the new imagery will only be measured decisively when we begin utilizing these advanced and most appropriate research instruments and scientific measuring techniques.

Visual Space: Effects on Comprehension and Recall of Information

In order to determine whether the factors of shape, direction, and motion of visuals in computerized television pictures influence viewer comprehension and recall of information, an exploratory study was conducted using the EKG, GSR, Eye-Track and a multiple choice questionnaire.

The stimulus materials were 9 segments of a computerized television sequence taken from a demonstration videotape called MIRAGE. The segments were edited for the study into 2, 3, 4, and 5 second segments. The shapes and colors, the direction, and the motion of visual elements within the screen were altered in each of the segments, whereas the content of the scenes (including sound) remained constant. The total duration of the videotape was 3 minutes and 13 seconds.

The subjects were selected from a variety of students between the ages of 14 and 30 years old, and they were pretested. The pretest recorded the subjects' reactions at a zero point of activity (shown in the datagram of the EKG, GSR, and Eye-Track) which is the key for the diagnosis of the actual test. A random sample of 9 students was retained and tested and only 7 tests were maintained for analysis. After they were briefed on the test procedure and the instruments, they were individually hooked up to 2 EKGs, 1 GSR, and to the Eye-Track apparatus. While they viewed the videotape, their physical reactions were recorded. As soon as they saw the video, they were given a multiple choice questionnaire which explored the degree of recall of information contained in the videotape.

The examination of the data gathered from the combined datagrams recorded by the EKG, GSR, and Eye-Track revealed that strong physical activity takes place when all three factors, shape, direction, and motion of the visual elements change. When the shapes of the objects were not readily distinguishable, their direction of motion was not easily anticipated and the speed of their motion was high, the psychophysiological instruments indicated stronger activity. Such recorded activity was even stronger in those sequences of the visual stimulus in which all three factors were at their extremes. A summary of the recorded biophysical activity of the subjects is presented in Appendix A.

The examination of the data obtained by the multiple choice questionnaire reveals that 54% of the overall elements presented in the visual stimulus, such as shape of objects, direction, and motion were correctly recalled by all subjects: more specifically 47% of them did identify the three major shapes of objects presented in the visual stimuli, but only 30% were able to describe precisely the details of those objects such as colors. Directions of motion on the Z-axis were correctly recalled by 66% of the subjects, whereas only 18% of them were able to give an accurate estimate of the speed of motion. It appears that regardless of the speed at which the objects are moving on the Z-axis, direction still attracts viewers' attention and is greatly recalled. Moreover, when motion and direction occur at a high speed in a length of time shorter than 5 seconds (see Appendix A) strong physiological reactions are recorded. This could suggest that speed and time might influence the recall of direction due to the intense physiological involvement of the viewer at that particular moment. Only 25% of the subjects were capable of identifying other elements. So it appears that the speed of motion reduces the viewers' ability to recall visual data. Finally 55% of the subjects described correctly the audio portion of the visual stimulus presented. However, sound was not accounted for in this study, since an effort was made to keep it constant.

It appears that direction and motion of objects along the Z-axis attract the attention of the viewer. But it also appears that speed reduces the ability to recall visual data. A histogram of the data obtained by the multiple choice questionnaire is presented in Appendix A.

Conclusions

It has been observed that technological advancements in television images have resulted in an increase of media imagery. It has also been speculated that viewer exposure to these images has increased. It was hypothesized that such developments are bound to have numerous psychophysiological effects on heavy viewers and users of such media.

In this paper it was argued that: 1. Empirical research in the composition of the depth axis in television images would be the most appropriate route to follow for the examination of the psychophysiological effects of these images on heavy viewers. 2. Examination of such effects should be centered on the three constructs of the theory of Z-axis staging: motion, depth of field, and direction. 3. The scientific study of the psychophysiological effects should be based on advanced and appropriate psychophysiological devices. 4. Viewer comprehension and recall of visual information depends on the placement of visual elements within the visual field. It is concluded that:

1. Empirical research on TV Z-axis staging which would aid in the study of the psychophysiological effects of new media imagery is conspicuously lacking.
2. The combination of rapid inward-outward movement, distorted depth of field, and forceful direction of visual elements placed on the Z-axis disturbs viewer comprehension and diminishes the aesthetic

appreciation of such images.

3. The psychophysiological instruments developed in the fields of psychology and neurophysiology are the most advanced and suitable tools of the study of such new and complex media images.
4. Empirical research on the suggested factors underlined in this study are warranted if we wish to achieve a better understanding of the visual communication media.

References

Arnheim, R. (1969). Art and visual perception: A psychology of the creative eye. Berkeley: University of California Press.

Averback, E. (1968). The span of apprehension as a function of exposure. In R. N. Harber (Ed.), Contemporary theory and research in visual perception (pp. 269-273). New York: Holt, Rinehart and Winston.

Aynsley, J. (1984). Visual literacy and the VCR. Broadcaster, 43, 6-8.

Beck, J. (1968). Perceptual grouping produced by line figures. In R. N. Harber (Ed.), Contemporary theory and research in visual perception (pp. 383-390). New York: Holt, Rinehart and Winston.

Behnke, R. R. (1970). Psychophysiological technologies. In P. Emmert & W. D. Brookes (Eds.), Methods of research in communication (pp. 429-452). Boston: Houghton Mifflin.

Brown, C. C., Giddon, D. & Dean E. (1965). Techniques of plethysmography. Psychophysiology, 1, 253-265.

De Long, A. J. (1983). Temporal experience and information processing: An examination of experimental relativity. Man Environment Systems, 13, 77-86.

Deregowski, J. B. (1972). Pictorial perception and culture. Scientific American, 227, 82-88.

Deregowski, J. B. (1971). Orientation and perception of pictorial depth. International Journal of Psychology, 6, 111-114.

Dondis, D. (1973). A primer of visual literacy. Cambridge, MA: The MIT Press.

Edmundson, M. (1984). It's all going according to Marshall's plan. Channels, 4, 49-55.

Ertl, J. (1975). The brain wave analyzer in schools and research. Neural Models, Las Vegas, Nevada, 4628 Pennwood Ave., 89102.

Evans, G. S. & Seddon, G. M. (1978). Responsiveness of Nigerian students to pictorial depth cues. Educational Communication and Technology Journal, 26, 303-320.

Fletcher, J. E. (1982). Communication and negative affect as indexed by positive-going skin potential responses. Paper presented to the First International Conference of the International Organization of Psychology, Montreal, Quebec.

Gardner, J. A. & Soliday, S. M. (1974). Picture quality judgements in a digital television system. Human Factors, 16, 139-145.

Gregory, R. L. (1968). Distortion of visual space as inappropriate constancy scaling. In R. N. Harper (Ed.), Contemporary theory and research in visual perception (pp. 364-369). New York: Holt, Rinehart and Winston.

Gulf and Western Research and Development Group. (1978). Eye-Track: Eye movement monitoring systems. Applied Science Laboratories. Walthan, MA: 365 Bear Hill Road, 02154.

Kimura, D. (1973). The asymmetry of the human brain. Scientific American, 231, 70-76.

Koff, R. H., Elman, D. & Wong, A. (1971). Bibliography and classification of the literature of pupilary response (pp. 1-104). HEW Office of Education, Contract No. O.E.C. G10-079.

Kolers, P. A. (1968). Some differences between real and apparent visual movement. In R. N. Harper (Ed.), Contemporary theory and research in visual perception (pp. 122-136). New York: Holt, Rinehart and Winston.

Kuipers, J. (1983). The next generation: Video games may give your kids a head start. TV Guide, 23, 23-28.

Lafayette Instruments Company. (1980). A catalogue of scientific and laboratory instruments for life science. In: P.O. Box 1279, Sagamore Parkway, 47902.

Levy, S. (1983). The fantastic worlds of the computer games. Channels, 3, 6-9.

Macworth, N. H. (1968). Visual noise causes tunnel vision. In R. N. Harper (Ed.), Contemporary theory and research in visual perception (pp. 434-437. Holt, Rinehart and Winston.

Malik, M. (1976). The psychophysiology of visual studies in film and television. Unpublished paper, Communication Studies Department, Concordia University, Montreal, Quebec.

Malik, M. (1978). Video psychology. Journal of the University Film Association, 30, 9-13.

Malik, M. (1980). Biometrical research for television. Paper presented to the BEA 1980 Annual Conference in Las Vegas, NE.

McKim, R. H. (1980). Experiences in visual thinking. Monteray, CA: Brooke/Cole Publishing Co.

Metallinos, N. (1979). Composition of the TV picture: Some hypotheses to test the forces operating within the TV screen. Educational Communication and Technology Journal, 27, 205-214.

Metallinos, N. (1983). Biometric research instruments and measuring techniques. In R. A. Braden & A. D. Walker (Eds.), Seeing ourselves: Visualization in a social context (pp. 171-176). Blacksburg, VA: Virginia Polytechnic Institute and State University.

Miller, G. A. (1968). The magical number seven plus or minus two: Some limits on our capacity of processing information. In R. N. Harber (Ed.), Contemporary theory and research in visual perception (pp. 187-202). New York: Holt, Rinehart and Winston.

Millerson, G. (1972). The technique of television production, (9th ed.) New York: Hastings House Publishers.

Murch, G. M. (1973). Visual and auditory perception. New York: Bobbs-Merril.

Siebert, W. M. (1978). Contribution of the communication sciences to psychology. American Journal of Psychology, 3, 66-166.

Spigel, I. M. (1968). Problems in the study of visually perceived movement: An introduction. In R. N. Harber (Ed.), Contemporary theory and research in visual perception (pp. 103-121). New York: Holt, Rinehart and Winston.

Taylor, J. F. A. (1964). Design and expression in the visual arts. New York: Dover Publications.

Treisman, A. M. (1968). Selective attention in man. In R. N. Harber (Ed.), Contemporary theory and research in visual perception (pp. 258-266). New York: Holt, Rinehart and Winston.

Young, L. and Sheena, D. (1975). Methods and designs: Survey of eye movement recording methods. Behavior Research Methods and Instrumentation, 7, 397-429.

Zettl, H. (1973). Sight, sound, motion: Applied media aesthetics. Belmont, CA: Wadsworth Publishing Co.

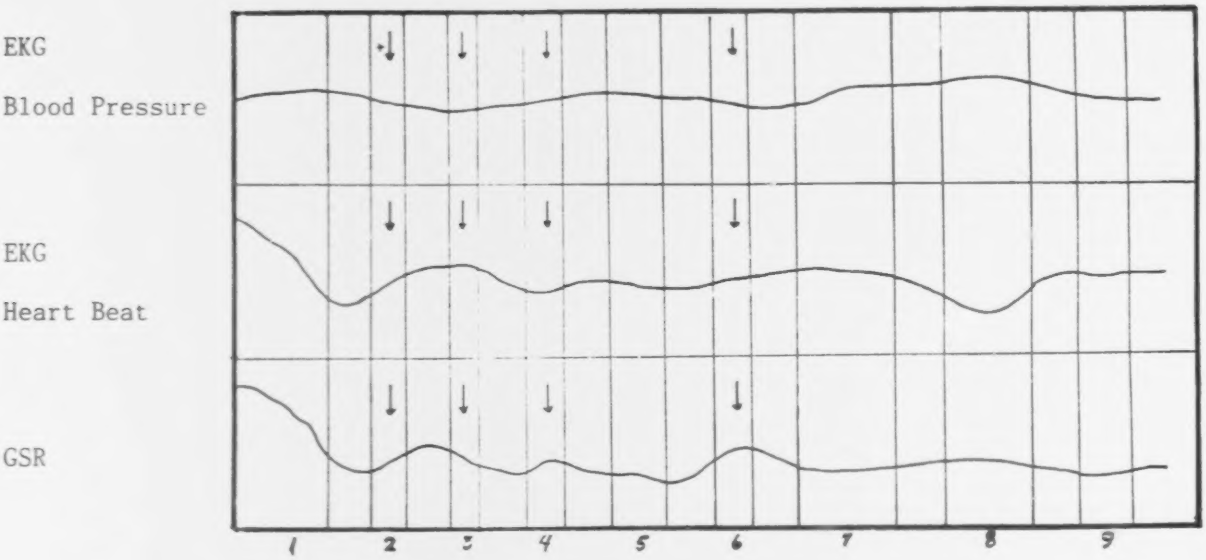
APPENDIX A

Summary of the Biometrical Tests

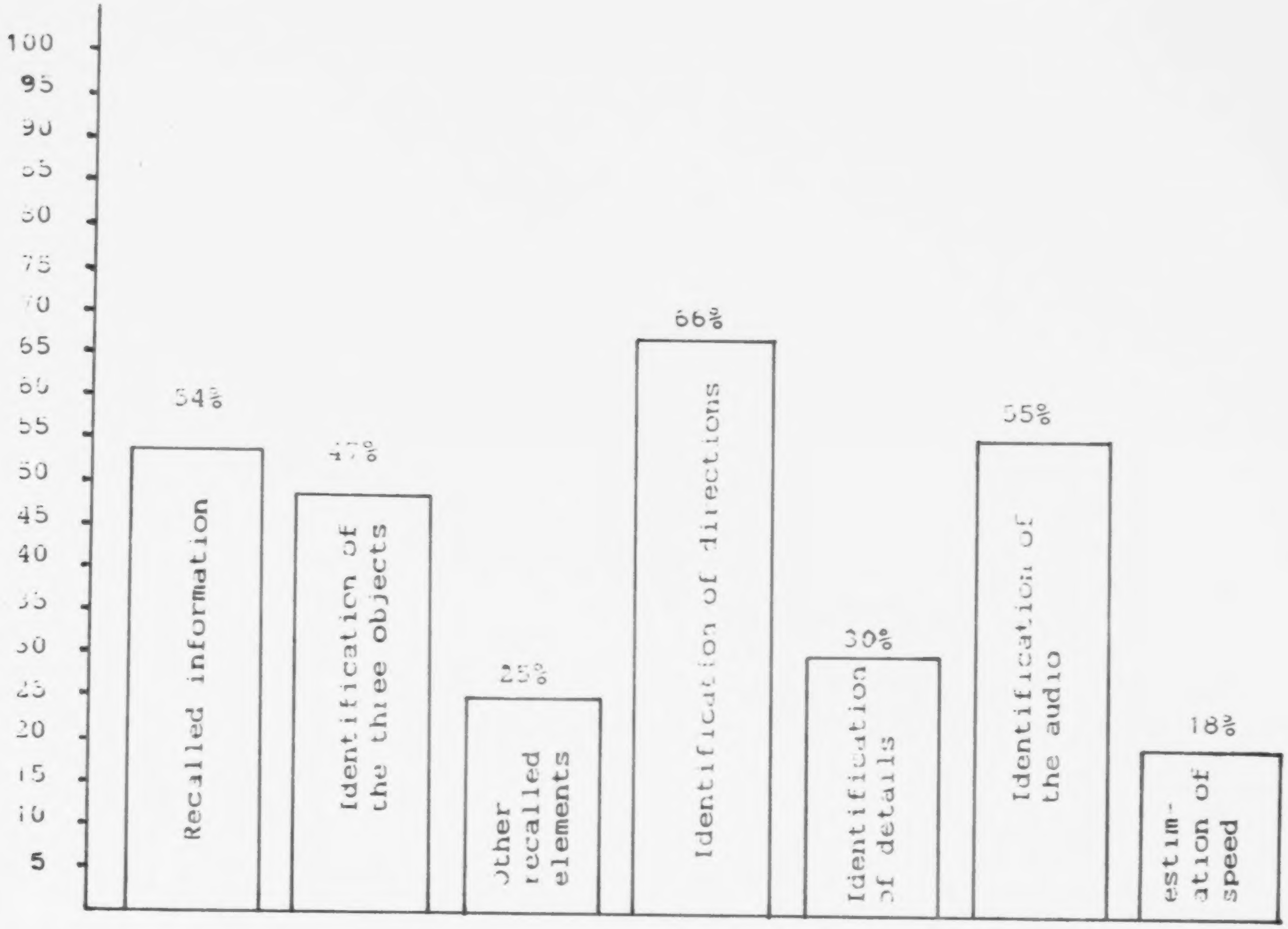
Summary of the Questionnaire

Summary of the Biometrical Tests

The Arrows below indicate where the Physiologica Reactions occur:



Summary of the Questionnaire



Ms. Sylvie Chartrand completed her B.A. in Communication Studies. She is presently working on her Master's degree in Media Studies. Her main interests in this field are visual literacy, media aesthetics, with emphasis on the biocybernetical communication research.

Dr. Metallinos is an Associate Professor of Communication Studies at Concordia University in Montreal. His research works in visual literacy related studies are drawn from neurophysiological findings on the asymmetrical functions of the human brain as they relate to the asymmetrical placement (dynamic composition) of visual elements within the visual field (film and television screens).

An Agenda for Research on Instructional Development

Michael Molenda
Associate Professor
Instructional Systems Technology
Bloomington, IN 47405

Presented at AECT Annual Conference
Atlanta
March 1, 1987

The ideas expressed in this paper are based on work done by the author in close collaboration with the Instructional Development Research Group in the Instructional Systems Technology department at Indiana University. The author acknowledges particular assistance from Ahmed Abdelraheem, Raja Maznah Raja-Hussain, Yong-Wee Tay, Saleem Waheeb, and Joanne Washington.

Running Head: Agenda for Research

Several years ago Durzo, Diamond, and Doughty (1979) provided a lucid analysis of research needs in instructional development. This paper aims to reassess and update the status of research on the broad process of instructional development and to suggest an agenda for future inquiry. It will analyze several conceptual problems that have constrained previous research, suggest resolutions of these problems, and provide a detailed framework for future research, including specific questions and suggestions for methods of inquiry.

Definitional Problem

Much to the detriment of communication among scholars, the terms "instructional design" and "instructional development" have been used interchangeably by many researchers and theoreticians over the past fifteen years. This problem has persisted even though the earliest papers in this field originally used "instructional development" as the broader term (e.g., Faris, 1968) and despite the fact that the most widely accepted definitional schema in the field of educational technology also defines instructional design as a subset of instructional development (AECT, 1977). Further, some authors fail to distinguish instructional development from the related processes of faculty development, student development, organizational development, and the like.

Two recent works have contributed greatly to a renewed clarification of this cluster of related concepts. First, Reigeluth's (1983) highly regarded (and aptly titled) book, Instructional-Design Theories and Models does indeed focus on instructional design issues. In it Reigeluth takes pains to distinguish instructional design from instructional development. When used technically, these terms are defined as follows:

> Instructional design . . . is the process of deciding what methods of instruction are best for bringing about desired changes in student knowledge and skills for a specific course content and a specific student population (p. 7).
>
> Instructional development is the process of prescribing and using optimal procedures for creating new instruction in a given situation (p. 8).

When speaking generally of the whole process of which these two are components, Reigeluth uses "instructional development" as the superordinate term.

Second, Bass and Dills (1984) entitle their wide-ranging anthology as Instructional Development: The State of the Art. The collection includes Robert Braden's seminal paper, "A Place in Space: ID's Universe," which has been hailed by reviewers for its definitional clarity. In it, the broad concept of instructional development is distinguished from the related concepts of faculty development (modifying attitudes and skills of faculty), organizational development (organization-wide effort to implement controlled change), student development (providing student with additional learning tools), and context development (planned efforts to change the environment surrounding an instructional system).

The importance of defining terms clearly is illustrated by Hannafin's recent overview (1986) of current and future directions of research. He variously refers to his focus of attention as "instructional design and technology," "instructional development and technology," "instructional development," "design of instruction," and "the ID field" (exact referent of the acronym is unspecified). His generalizations are often difficult to evaluate because the referent is unclear. For example: "Perhaps due to the strong influence of the behavioral sciences on the ID field . . . experimental paradigms have dominated published research" (p. 25). This may be true of instructional design, but not of instructional development. In fact, Hannafin raises a number of legitimate issues and gives a useful set of recommendations for encouraging more and better research in any field. But the prescriptions are generic; this is expectable given the "shotgun" diffuseness of the diagnosis. This paper aims to suggest a more specific set of recommendations regarding a framework and agenda for future instructional development research.

For the sake of clearer communication, I propose that the term "instructional development" be used to refer to the systematic process of analyzing, designing, producing, evaluating, and implementing instructional systems or components thereof. By this definition, "instructional design" is a subset of instructional development, referring to that part of the process devoted to specifying instructional treatments most appropriate for attaining particular objectives by a given set of learners. It is the part of the process that fits between learner/task analysis and selection/production of methods/materials. Its outcome is the set of specifications for the methods and materials.

Review of Previous Research

Two recent critiques of research in educational/instructional technology by Winn (1986) and Gerlach (1984) provide a convenient point of departure for a review of previous research on instructional development (ID). First, both Winn and Gerlach deal with the whole domain of educational/instructional technology and they both implicitly treat the issues of "learning from media" as the Heartland of the field; however, they do allude to instructional design/development as a major subset of the larger field. Unfortunately for our present purposes, they both use the terms design and development interchangeably. Inferring from the variables they discuss and the examples they use, it appears that both authors usually are focusing on what is here called instructional design. For example, in referring to recent findings on "instructional development," Winn says, "We are beginning to discover the relationships among task, student characteristics, methods and strategies that students actually use" (pp. 8-9). Such a statement indicates a fixation with design issues, as contrasted with the broad concerns--social, political, and economic--that are salient to a complex process conducted by people in various human settings.

Because of such biases in recent research syntheses it is difficult to get a sense of where we stand in instructional development research above and beyond the design issues. Consequently, I recently undertook an independent review of research with the assistance of several graduate students. Our search centered around the scholarly journals in the field of educational/instructional technology plus relevant dissertations catalogued in Dissertation Abstracts International. One of the more promising bodies of literature that has not been adequately explored is that of government/military research on ID. Two very recent articles, by McCombs (1986) and Ellson (1986), indicate that there is a substantial reservoir of government-sponsored research on ID conducted in military and foreign educational settings that has not yet been integrated adequately into the academic mainstream. McCombs's and Ellson's observations are referred to later in this paper, but the primary sources have not yet been reviewed.

In general, if one excludes studies dealing primarily with instructional design concerns (relationships among various treatments, learners, and tasks), the major scholarly journals closest to the instructional development (ID) field carry relatively few reports of research on ID. That is, few articles were found that reported quantitative or qualitative findings on the ID process itself; the sub-processes of analysis, selection/production, evaluation, or implementation; professional roles of instructional developers; or socioeconomic aspects of ID. Six such studies were found in Journal of Instructional Development since 1978 (Nalbone, 1979; Guzy et al., 1979; Klein & Doughty, 1980; Vanek & Kennedy, 1981; Willis, 1983; Higgins & Reiser, 1985); of these, four are basically case studies.

In Educational Communication and Technology Journal (and its predecessor AV Communication Review) since 1974, six studies reported data on ID phenomena (Hoban, 1974; Savage, 1975; Kandaswamy et al., 1976; Kerr, 1977; Burton & Aversa, 1979; Shrock, 1985); another (McCombs, 1986) synthesized evidence from earlier field research.

NSPI's Improving Human Performance Quarterly in the 1970s and--to a lesser extent--Performance & Instruction in the 1980s have also carried a number of reports based on empirical research on ID (Short, 1973; Smith et al., 1976; Nathenson et al., 1977; Smith, 1978a; Smith 1978b; Krug et al., 1979; Golas, 1983; Wager, 1983).

Other journals, including Educational Technology, Phi Delta Kappan, and Educational Psychologist, carry ID research articles on occasion. But, even looking only at the mainstream journals, ID research occupies a rather small niche, representing no more than 5 percent of the total articles carried in these journals.

In sheer quantity, unpublished dissertations comprise the single largest source of research on ID, contributing perhaps half of the total "knowledge base" in this field. Eighteen dissertations are cited in the References, representing those studies that fell closest to the domain of ID as defined here (again, excluding instructional design studies) and which most clearly are based on observational data gathered under laboratory or field conditions. Excluded are a dozen or more questionnaire surveys which seemed to serve no theoretical purpose beyond describing some audience's "awareness" or "attitude toward" ID. Examples of the dissertations included in this review are: Patterson (1981) who interviewed developers and examined documents in ten corporate settings to determine the extent to which they employed ID procedures; Scudder (1982) who used a questionnaire to survey corporate instructional developers to determine the extent of their use of ID procedures; Orban (1982) who did an ethnographic study, observing the consultation interactions between a developer and several clients; and Holsclaw (1974) who surveyed thirteen ID agencies in higher education concerning their working guidelines, distilling these into over 100 "heuristics" for conducting ID.

It's difficult to generalize about the set of studies gathered in this search. They represent every point on the quantitative/qualitative spectrum, from Kandaswamy, Wager, and Nathenson on the experimental design end of the scale to Shrock and Chen on the naturalistic end. What may be most notable is that there is no prevailing paradigm evident. Contrary to what other reviewers consistently claim is the pattern in media and instructional design research, the experimental psychological paradigm is followed in a minority of these studies. It appears that there is still a ready market for exemplars to set the pattern(s) for future research in this area. The field does not appear to have yet decided what is a "good" model for instructional development research.

New Approaches Advocated

At least since Salomon and Clark's (1977) critique of the methodology of research on instructional media and technology there has been an awareness of the limitations inherent in experimental laboratory research in the whole domain of Educational Technology. Salomon and Clark focused on the dilemma of internal vs. external validity. As they put it, "the more it [media research] moved into the deeper layers of understanding media, the farther it went from the world of education" (p. 106). Their principal recommendation was to buttress external validity by moving toward research in natural settings, and they suggested several pseudo-experimental designs to maintain some degree of internal validity.

Salomon and Clark's admonition has been echoed with variations by many voices since then. Driscoll (1984) compiled an extensive list of alternative research paradigms, each with example studies, suitable to different questions in the domain of "instructional systems." She mentioned quasi-experimentation, meta-analysis, case study and ethnography, systems-based evaluation, cost-effectiveness analysis, and techniques and model development. Although some of her examples could be construed as instructional development (ID) research, most fall into the larger domain of Educational Technology or the instructional design subset.

Heinich's (1984) classic essay on the proper concerns of instructional technology speaks to ID as well in calling for systems analyses and other such "engineering" type decision-oriented studies. His main appeal is that the very nature of the instructional technology field, being based in professional practice, demands a shift away from conclusion-oriented research, which so far has contributed more to the knowledge base of educational psychology than to instructional technology. Incidentally, Cunningham (1986) in his recent critique of "method A versus method B" comparison studies, questions the assumptions such studies are based on and denies that they have contributed to the knowledge base even of educational psychology.

Stephen Kerr (1985), in his introduction to a theme issue of ECTJ points out a "blind spot" in the study of educational communications and technology: "questions relating to the ways in which educational technology affects the social relationships among those who work and learn in educational institutions and how it may change the nature of those institutions themselves" (p. 3).

The importance of social issues has been pointed out most persuasively and most directly for instructional development by Schwen and his colleagues (1984). They emphasize that the practice of ID demands an understanding of social processes since ID is itself a social process (i.e., team planning) and a social intervention (i.e., working with instructor clients) which invariably takes place within a complex social system.

A Conceptual Framework for ID Research

In their perceptive analysis of ID research needs, Durzo, Diamond, and Doughty (1979) defined their domain to include not only instructional design as a subset of instructional development, but also faculty development (FD) and organizational development (OD). This attempt to update their work will specifically exclude FD and OD simply because they are clearly separate constructs (as Braden argues) with different critical attributes. I will also differ from Durzo, Diamond, and Doughty by restricting the concept of "instructional design" more narrowly than they, limiting it (as Reigeluth argues) to the specification of instructional treatments. Finally, I will follow the lead of Heinich, Kerr, and Schwen et al. by expanding ID's social concerns beyond the project management and client relationship categories suggested by Durzo, Diamond, and Doughty.

Taking into consideration the framework proposed by Durzo, Diamond, and Doughty, adding to it the topics covered in previous research, and the social issues raised by Kerr, Heinich, and Schwen et al., and filling in obvious gaps, I have developed the following general framework as a beginning point in the search for a comprehensive framework for future ID research. I will first present a broad outline, then flesh in the details, section by section. Note that the outline is divided into two parts: Decision-oriented issues and Conclusion-oriented issues. Not only do these two directions appeal to different consumers, but they also imply qualitatively different questions.

DECISION-ORIENTED ISSUES

I. Administrative and policy issues of ID agencies

II. Internal organization/management of ID teams

III. Interaction with clients

IV. Social/political relationships with supra-systems

V. Optimization of ID procedures

  A. Overall ID model

  B. Needs analysis

  C. Learner analysis

  D. Task analysis

E. Environmental analysis

F. Objectives specification

G. Instructional design (NOT ELABORATED IN THIS PAPER)

H. Prototype construction

I. Formative evaluation/revision

J. Summative evaluation/revision

K. Implementation of developed instruction

CONCLUSION-ORIENTED ISSUES

I. Definition of instructional development (ID)

II. The value of ID

Let us proceed to flesh out the details of these issues, their sub-issues, and the research questions that they imply.

I. Administrative and policy issues of ID agencies. Durzo, Diamond, and Doughty suggest a number of issues to be pursued in this category.

A. The costs and benefits of ID

1. What organizations should consider doing ID?

2. What are the costs of doing ID?

3. What are the benefits of ID?

4. How can cost/benefit tradeoffs be calculated?

5. How much time does ID require?

6. What variables in the ID process affect time expenditures? Money costs?

B. Administrative setup

1. Where should an ID agency be placed in the organizational hierarchy?

2. Who should direct an ID agency? What rank in the organization? Reporting to whom?

3. What should be the organizational relationship between ID agency and production agency? evaluation agency? training agency? other related agencies?

C. Role of ID agency

1. What services are valued by instructor-clients?
2. What services are valued by administrator-clients
3. What mix of services is most likely to make the largest instructional improvement impact?
4. What mix of services is most likely to lead to longevity of the agency?

D. characteristics of ID agency

1. What competencies should be represented on the staff?
2. What variables affect the optimal staff size (e.g., size of supra-system in terms of budget, employees; number of projects undertaken)?
3. On what basis should ID services be centralized or decentralized?

E. Approaches taken to ID

1. What are the tradeoffs involved in emphasizing product development vs. training clients to solve their own problems? What are the costs of each approach? Benefits of each?
2. What attitudes or skills should be included in client training?

F. Project Generation/Selection

1. Is it more productive to pursue a few large projects or many small ones? Which approach contributes more to overall instructional improvement? Which leads to greater longevity of the ID agency?
2. Should projects be generated internally from an analysis of organizational needs or externally from "walk-in" requests by instructor-clients?
3. What diffusion strategy generates more project proposals?
4. What sorts of incentives attract clients? What factors in the organizational climate have an effect on who supports ID and how strongly?
5. By what criteria should project proposals be evaluated and prioritized?
6. Who should set criteria for prioritization? What are the advantages/disadvantages of advisory boards?

II. Internal organization/management of ID teams.

A. Personnel

1. What competencies are needed on different types of project teams?

2. How many people can work productively on one project? Does adding staff increase or reduce the time needed to complete a project?

3. Who should lead the ID team?

4. What group dynamics skills are necessary for team members?

B. Budgeting: time and money

1. What administrative factors affect the cost of ID? How?

2. What factors affect manpower needs? What factors determine time requirements?

C. Internal organization

1. Under what sorts of supervision and operating rules do different teams work best? Democratic? Authoritarian? Laissez-faire?

2. What are useful methods of team building? . . . decision making? . . . sharing power/control? . . . conflict management?

3. What sorts of documentation should be carried on routinely? . . . by teams? . . . by agency?

III. Interaction with clients.

A. Client attributes

1. Who volunteer to be ID clients?

2. What attributes of clients tend to be functional/dysfunctional?

3. On what basis should clients be selected?

B. Developer attributes

1. What developer attributes tend to be functional/dysfunctional?

2. How can rapport be established? To what extent and in what ways does rapport contribute to project success?

C. Strategies of interaction

1. Are there predictable phases in the developer-client psychological relationship? How can these be recognized? What strategies can be used to manage this relationship?

2. What are the advantages/disadvantages of various strategies of managing this relationship (e.g., regarding goal-setting, decision making)?

3. What are appropriate tactics for each strategy (i.e., components of "consulting style")?

IV. Social/political relationships with supra-systems.

A. Organizational settings

1. How can the various organizational settings be classified (e.g., public/private school, public/private college, corporation, government agency)?

2. What attributes of the setting have an effect on acceptance or productivity of ID activities (e.g, "traditional" vs. "innovative" cultures)?

3. What elements in the organizational setting generate political consequences for ID? Which elements in the supra-system? . . . in the supra-supra-system? . . . in higher echelons?

4. What elements within or beyond the organization generate economic consequences for ID? Which are short-term, which are long-term?

B. Goals and values

1. How do the goals/values of ID correspond with the goals/values of the different actors?

2. How receptive are different "corporate cultures" to the values of ID?

3. Do different actors (e.g., administrators vs. instructors) differ in their acceptance of the values of ID?

4. Do unionized and non-unionized organizations differ in their receptivity to ID?

C. Political strategies

1. What strategies can be used to enhance the social/political/economic position of ID agencies (e.g., role of advisory boards)?

2. What are the political consequences of different operating strategies (e.g., project selection policies)?

3. What are the social/political/economic incentives of the different actors?

D. ID effects on the organization

1. What effects does an ID agency have on the organization (e.g., as a model of rational decision-making)?

2. Does having an effect on the organization create political problems (e.g., professional jealousy)?

E. National cultures

1. To what extent do different national cultures affect the acceptance of ID?

2. Do attributes of different national cultures affect the productivity of ID agencies?

V. Optimization of ID procedures. As is the case with any field of practice, a good deal of the inquiry in ID has been conducted with the objective of improving professional practice. The concerns in this area revolve around identifying useful techniques for doing ID.

Many of the early dissertations in the ID field were aimed at discovering and testing overall models of ID (Stowe, 1971; Belmore, 1973; Holsclaw, 1974). Very recently, at least two knowledgeable researchers have felt that sufficient evidence exists to make a judgment as to the efficacy of the most prominent ID models. Douglas Ellson (1986) in his systematic review of research studies in which technological instructional methods have been compared with conventional methods identifies several broad techniques (e.g., programmed learning and programmed teaching) that consistently yield higher "relative productivity ratios" than conventional instruction. Among such successful techniques he includes "performance-based instructional design" in which "information obtained in one tryout of a particular teaching procedure with one group of pupils is used as the basis for revising the design of that procedure for the group. . ." (p. 119).

Ellson cites as the basis for his judgment reports of several large-scale applications of ID procedures in elementary schools in the U.S., in elementary schools in Southeast Asia, and in U.S. military training. Interestingly, the military ID model that he cites, "Interservice Procedures for Instructional Systems Development (ISD)" is the same one examined in depth by McCombs (1986). McCombs surveys a much broader range of literature on ISD and finds that there is a widespread perception, especially in the military, of the failure of the ISD model. She attributes this perception to the users' "failure to maintain a total systems perspective and of reducing the problem focus to the development of self-paced or individualized materials" (p. 71). She feels that systematic ID must be a complex, creative process applying higher order analytical skills. Reduced to mere routine procedures (as is the temptation in bureaucratized ID agencies) the model loses its effectiveness. McCombs charts a course for continuing research on the overall effectiveness of ID models by generating a set of "empirically identified factors in the successful implementation of ID."

Questions in this area can be clustered first under the general heading of ID models overall, and then under headings signifying each of the elements in the ID process.

A. ID models overall

   1. How can different ID models be classified?

   2. Do different models differ in their effects, given that each is applied conscientiously?

   3. What factors are associated with greater impact on instructional improvement? . . . on continued support of ID activities?

   4. What are the relative strengths and limitations of each type of ID model?

   5. On what basis should a developer select a model to follow?

B. Needs analysis: What are optimal procedures for needs analysis?

C. Learner analysis: What are optimal procedures for learner analysis?

D. Task analysis: What are optimal procedures for task analysis?

E. Environmental analysis: What are optimal procedures for environmental analysis?

F. Objectives specifications: What are optimal procedures for objectives specification?

G. Instructional design: What are optimal procedures for instructional design? That is, what design rules yield better decisions about matching treatment with audience with learning task?

H. Prototype construction: What are optimal procedures for prototype construction?

I. Formative evaluation/revision: What are optimal procedures for formative evaluation/revision?

J. Summative evaluation: What are optimal procedures for summative evaluation?

K. Implementation: What are optimal procedures for implementing developed instruction?

CONCLUSION-ORIENTED ISSUES

Researchers, especially those approaching ID from the perspective of educational psychology, tend to begin by raising conclusion-oriented questions. Their agenda is dominated by a concern for reaching conclusions about the value of ID relative to other instructional planning methods. This perspective is typified by studies comparing "method A" with "method B." Such studies often make implicit assumptions about the hypothetical constructs of "instructional development" and "conventional instruction." They assume that these constructs actually exist and they have certain attributes. The problems with these assumptions have been expressed cogently by Gerlach and by Clark in a number of articles over the past decade; Gerlach (1984) and Clark (1985) are recent presentations of these issues.

It is at least equally logical to defer conclusion-oriented questions until researchers have worked out a "feel" for the phenomena under discussion by means of extensive observation under field conditions. Ideally, as in other domains of theory/practice, a dialectic evolves in which theoretical frameworks suggest directions for specific investigation, and the results of those investigations are fed back into clarifying the relevant constructs and adjusting the theoretical framework.

Questions in this area tend to revolve around the philosophical concerns of what is true, what is good, and what is beautiful.

I. Definition of instructional development.

A. Meanings

1. What meanings are attributed by users of the term (inferred from their usages)?

2. What meanings can be inferred from observation of ID programs?

3. What meanings are proposed authoritatively?

B. Critical attributes

1. As a hypothetical construct, what are the critical attributes of ID?

2. To what extent does this hypothetical construct exist in reality? (Is anyone really doing ID?)

II. The value of instructional development.

A. Effectiveness

1. Is ID more or less effective than alternative methods of planning instruction?

2. Does the use of ID lead to superior learning?

B. Cost/benefit

1. What are the expected cost/benefit tradeoffs of ID?

2. What are the most meaningful elements to count as "costs"? . . . as "benefits"?

C. Side effects

1. What are the short-term side effects of ID?

2. What are the long-term side effects of ID? . . . on learners? . . . on organizations? . . . on societies?

Phenomena to Study and Methods of Observation

Given the above agenda of questions to be answered, how would one go about attempting to cast light on these processes? What phenomena would the researcher wish to observe? Under what conditions of control?

First, since ID is by definition a process involving interaction among humans and they necessarily operate within social systems, one of the most important classes of phenomena to be observed is the behavior or participants in the ID process. Participants include both those directly involved in ID projects and those within the organizational setting who have some relationship to ID. Gerlach (1984) argues that prescriptive rules can be developed by looking at the behavior of the developer as a dependent variable (p. 27).

Having determined that a major class of phenomena to be studied is that of the behavior of participants in ID, how does one observe such behavior? There are at least three broad possibilities:

1. Direct observation of behavior *in vivo*
    - participant observation, nonparticipant observation, ethnography
2. Indirect observation
    - perceptions of participants (e.g., through questionnaires), post hoc recollections of participants (e.g., through interviews), examination of artifacts of ID activities (e.g., ID documentation, organization records)
3. Simulated observation
    - contrived ID situations observed by means of experimental or quasi-experimental designs (e.g., comparison studies).

Another major class of phenomena to be studied is that of the effects of ID products on their intended audiences. What changes in knowledge, skill, and attitude result from exposure to developed instruction? From measurement of changes in ability or attitude we can infer the efficacy of different ID interventions. Questions of this sort lend themselves to the traditional research paradigms carried over from educational psychology, experimental, and quasi-experimental designs.

The experimental paradigm applied to student achievement lends itself well to answering questions about the products of ID but less well to questions about the processes of ID. For example, a review of research on formative evaluation by Baker and Alkin (1973) reveals a rich vein of empirical research on this aspect of ID. They cite some two dozen studies in which various methods of formative evaluation have been tried out on real or simulated ID products. This element of the ID process—formative evaluation—perhaps because it lends itself to concrete testing with actual learners, has been one of the most popular subjects for empirical study in the domain of ID. More recent studies (Kandaswamy et al., 1976; Nathenson, 1979; Burton & Aversa, 1979; Golas, 1983; Wager, 1983; Israelite, 1984) continue to demonstrate the possibility of making inferences about optimal ID procedures based on the learning effects of those procedures. However, as we move backward in the ID process, away from the final product, the causal links become more and more tenuous. That is, it would be difficult to judge the efficacy, for instance, of a given task analysis technique based on the criterion of learner achievement because so many other intervening processes come between that task analysis decision and the ultimate effect on the learner. For example, the task may have been analyzed beautifully, but the analysis may have been presented to the learner by means of a boring delivery vehicle. Further methodological work is needed to clarify the current murkiness and lack of consensus regarding methods for evaluating these process phenomena.

Methodological disputes in the domain of ID tend to revolve around tradeoffs between internal and external validity. That is, employment of rigorous experimental designs with sophisticated statistical treatments enhances the internal validity (control over variables) at the expense of external validity (applicability of findings to real-life settings). The whole thrust of the naturalistic inquiry movement which is well under way in this field is to gain meaningfulness, even at the sacrifice of generalizability. (The sacrifice, of course, is not absolute; Schwen [1977] discusses ways in which generalizability can be enhanced, even in case studies.)

The issue is not whether research in ID ought to adhere more to one paradigm than another. The issue is to select that paradigm and those methods that are most likely to cast light on the particular phenomena under scrutiny in a given study. It should be clear by now that even the rather restricted topic of instructional development encompasses phenomena ranging from learners' cognitive processing of specific stimuli to the political ramifications of different project management schemes. The former may be studied profitably by experimental, psychological methodology, the latter by holistic, naturalistic observation. As Winn (1986) expressed aptly,

> I am bothered by the feeling I get that proponents of each class of method are proposing alternatives to rather than complements to the other class of method. Given the eclectic nature of research questions in our discipline (and in Education generally), we must have at our disposal a whole battery of methods to deal with the different types of things we need to find out (p. 20).

Thankfully, further steps down the path toward an agenda for research on ID can be guided by such aids as the criteria for inquiry advocated by Schwen (1977) and the logistical recommendations of Hannafin 91986). Researchers need not travel alone on this journey.

REFERENCES

Albero-Andres, M. (1983). The use of Agency for Instructional Television instructional development model in the design, production, and evaluation of the series "Give and Take." Dissertation Abstracts International, 43.

Association for Educational Communications and Technology (AECT). (1977). The definition of educational technology. Washington, DC: Author.

Baker, E. L., & Alkin, M. C. (1973). Formative evaluation of instructional development. AV Communication Review, 21(4), 389-418.

Bass, R. K., & Dills, C. R. (Eds.). (1984). Instructional development: State of the art, II. Dubuque, IA: Kendall/Hunt.

Belmore, W. E. (1973). The application of a cost analysis methodology to the design phase of instructional development. Dissertation Abstracts International, 33, 5996.

Bennett, T. (1985). Major field techniques and instruction levels by Canadian instructional developers. Canadian Journal of Educational Communication, 14(2), 6-7, 18-22.

Burton, J., & Aversa, F. (1979). Formative evaluation information from scripts, scratch tracks, and rough cuts: A comparison. Educational Communication and Technology Journal, 27(3), 191-194.

Carl, D. R. (1978). A front-end analysis of instructional development in instructional television. (Doctoral dissertation, Indiana University, 1977). Dissertation Abstracts International, 38.

Chen, A. (1985). The role of instructional consultation for educational development in higher education. Unpublished doctoral dissertation, Indiana University.

Clark, R. E. (1985). Evidence for confounding in computer-based instruction studies: Analyzing the meta-analyses. Educational Communication and Technology Journal, 33(4), 249-262.

Cunningham, D. J. (1986). Good guys and bad guys. Educational Communication and Technology Journal, 34(1), 3-7.

Driscoll, M. P. (1984). Alternative paradigms for research in instructional systems. Journal of Instructional Development, 7(4), 2-5.

Durzo, J. J., Diamond, R. M., & Doughty, P. L. (1979). An analysis of research needs in instructional development. Journal of Instructional Development, 2(4), 4-11.

Ellson, D. G. (1986). Improving productivity in teaching. Phi Delta Kappan, 68(2), 111-124.

Faris, K. G. (1968, November). Would you believe--an instructional developer? Audiovisual Instruction, pp. 971-973.

Faust, S. M. (1980). Instructional developer as content specialist: Three case studies utilizing the instructional development-operations research model. Educational Technology, 20(9), 5-12.

Fry, B. L. (1984). A descriptive study of elementary teachers' instructional planning. Dissertation Abstracts International, 46.

Gerlach, V. (1984). Trends in instructional technology research. In J. W. Brown & S. N. Brown (Eds.), Educational Media Yearbook (pp. 24-33). Littleton, CO: Libraries Unlimited.

Golas, K. C. (1983). Formative evaluation effectiveness and cost. Performance and Instruction, 22(5), 17-19.

Guzy, L. T., et al. (1979). Instructional development project: Five-semester report on an innovative Introduction to Psychology course. Journal of Instructional Development, 2(3), 20-30.

Hannafin, M. J. (1986). The status and future of research in instructional design and technology. Journal of Instructional Development, 8(3), 24-30.

Heinich, R. (1984). The proper study of instructional technology. Educational Communication and Technology Journal, 32(2), 67-87.

Higgins, N., & Reiser, R. A. (1985). Selecting media for instruction: An exploratory study. Journal of Instructional Development, 8(2), 6-10.

Hoban, D. (1974). The instructional developer. AV Communication Review, 22(4), 433-466.

Holsclaw, J. E. (1974). The development of procedural guidelines for the systematic design of instruction within higher education. Unpublished doctoral dissertation, University of Southern California.

Israelite, L. (1984). The use of student self-evaluation data during formative evaluation. (Doctoral dissertation, Arizona State University, 1983). Dissertation Abstracts International, 44, 2123.

Kandaswamy, S., Stolovitch, H., & Thiagarajan, S. (1976). Learner verification and revision. AV Communication Review, 24(3), 316-328.

Kerr, S. T. (1977). Are there instructional developers in the schools? AV Communication Review, 25(3), 243-267.

Kerr, S. T. (1985). Introduction: Asking new questions about technology and the social world of education. Educational Communication and Technology Journal, 33(1), 3-8.

Klein, J., & Doughty, P. (1980). Evaluation: A case study of an innovative program in higher education. Journal of Instructional Development, 3(3), 19-24.

Krug, D., Arick, J., Scanlon, C., Almond, P., Rosenblum, J., & Border, M. (1979). Evaluation of a program of systematic instructional procedures for preverbal autistic children. *Improving Human Performance Quarterly*, *8*(1), 29-41.

McCombs, B. L. (1986). The Instructional Systems Development (ISD) model: A review of those factors critical to its successful implementation. *Educational Communication and Technology Journal*, *31*(4), 187-199.

Mengel, N. S. (1983). The acceptability and effectiveness of materials revised using instructional design criteria (Gagne). *Dissertation Abstracts International*, *43*, 3299.

Nalbone, P. J. (1979). Improving readiness for change and innovation: A case study. *Journal of Instructional Development*, *3*(1), 2-9.

Nathenson, M. B. (1979). An experimental study of developmental testing as a component of the instructional design process. (Doctoral dissertation, Catholic University of America, 1978). *Dissertation Abstracts International*, *39*.

Nathenson, M. B., Henderson, E. S., & Hodgson, B. K. (1977). Developmental testing really does work. *Improving Human Performance Quarterly*, *6*(4), 167-177.

Orban, D. A. (1982). An ethnographic study of consultation to improve college education. *Dissertation Abstracts International*, *42*(12), 5040.

Patterson, A. C. (1981). Instructional development procedures and practices in selected training and human resources development programs. (Doctoral dissertation, Indiana University, 1980). *Dissertation Abstracts International*, *41*, 1354.

Reigeluth, C. M. (Ed.). (1983). *Instructional-design theories and models*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Rhee, K. (1983). Factors which constrain instructional development in medical schools as perceived by instructional developers. (Doctoral dissertation, Indiana University, 1982). *Dissertation Abstracts International*, *43*.

Rutt, D. (1979). *An investigation of the consultation styles of instructional developers*. Unpublished doctoral dissertation, Indiana University.

Salomon, G., & Clark, R. E. (1977). Reexamining the methodology of research on media and technology in education. *Review of Educational Research*, *47*(1), 99-120.

Savage, A. L. (1975). Increasing empathetic capabilities of instructional developers: Evaluation of a three phase instructional strategy. *AV Communication Review*, *23*(4), 415-426.

Schwen, T. S. (1977). Professional scholarship in educational technology: Criteria for judging inquiry. *Educational Communication and Technology Journal*, *25*(1), 5-24.

Schwen, T. S., Leitzman, D. F., Misanchuk, E. R., Foshay, W. R., & Heitland, K. M. (1984). Instructional development: The social implications of technical interventions. In R. K. Bass & C. R. Dills (Eds.), *Instructional development: State of the art, II* (pp. 40-50). Dubuque: IA: Kendall/Hunt.

Scudder, R. A. (1982). A survey of the use of instructional development in selected business, industries, and government organizations in Colorado. *Dissertation Abstracts International*, *42*(1), 79.

Short, J. (1973). A case study of task analysis. *Improving Human Performance Quarterly*, *2*, 60-67.

Shrock, S. A. (1985). Faculty perceptions of instructional development and the success/failure of an instructional development project: A naturalistic study. *Educational Communication and Technology Journal*, *33*(1), 16-25.

Smith, L. M., & Pohland, P. A. (1969). Participant observation of the CAI program. In H. Russell (Ed.), *Evaluation of computer-assisted instruction program: Interim report*. St. Ann, MO: Central Midwestern Regional Educational Laboratory (CEMREL).

Smith, M. E. (1978a). Performance indices for managing a training development organization: Two years of experience. *Improving Human Performance Quarterly*, *7*(3), 303-318.

Smith, M. E. (1978b). An illustration of evaluation processes, design features and problems. *Improving Human Performance Quarterly*, *7*(4), 337-350.

Smith, M. E. (1985, February). Recognizing research opportunities. *Performance & Instruction Journal*, pp. 9-12.

Smith, M. E., O'Callaghan, M., Corbett, A. J., Morley, B., & Kamradt, I. (1976). An example of meta-evaluation from industry. *Improving Human Performance Quarterly*, *5*(3-4), 168-182.

Stiehl, R. E., & Streit, L. C. (1984). Factors assuring success of an instructional systems model. *Educational Technology*, *24*(8), 23-27.

Stowe, R. A. (1971). Investigation of a mathematical model for managing instructional development time. *Dissertation Abstracts International*, *31*, 3185.

Vanek, E. P., & Kennedy, W. R. (1981). Planning for instructional improvement in medical education: A case study. *Journal of Instructional Development*, *4*(3), 2-5.

Wager, J. C. (1983). One-to-one and small group formative evaluation. *Performance and Instruction*, *22*(5), 5-7.

White, R. T., & Gagne, R. M. (1974). Past and future research on learning hierarchies. Educational Psychologist, 11, 19-28.

Willis, B. (1983). A comparison of the leadership behaviors of instructional designers in higher education and industry. Journal of Instructional Development, 6(3), 2-5.

Winn, W. (1986, January). Emerging trends in educational technology research. Annual conference of the Association for Educational Communications and Technology, Las Vegas.

Microcomputer Interactive vs. Traditional Associative Learning in a Paired-Associative Recall Task

Barbara S. Newhouse, Ph.D.
Assistant Professor of Education
Department of Curriculum and Instruction
Kansas State University
Manhattan, KS 66506

The implementation of microcomputers into the schools has become immediate and widespread (Chambers and Sprecher, 1984). Although industry is ahead of public education in both acceptance and utilization of microcomputers, a survey (Time, 1983) reported that sixty-eight percent of registered voters felt the microcomputer would improve the quality of their children's education. Unlike other educational movements, such as programmed instruction and television, the microcomputer did not evolve from within, but for the most part from business and industry (Bear, 1984).

The field of educational media depends on a theoretical learning base to support applications to instruction and the significant increases in learning due to technology (Saettler, 1979). A key learning theory that is well documented in the literature and supports the contributions of the microcomputer for classroom learning is that of association in verbal learning (Kolesnik, 1976).

Association learning involves stimuli, such as those presented by a teacher, a film, a textbook or a microcomputer and the response to those stimuli by the learner. A common procedure for analyzing verbal associative learning in stimulus-response terms is the method of paired-associates (Deese and Hulse, 1967). With this method, the subject learns pairs of verbal items. When presented with the first member of each pair (the stimulus) the subject must pair the second member (the response). The typical paired-associate learning study uses ten to twelve pairs, such as TIV-GEX or ZPH-HAPPY.

Many examples of paired-associations are representative of the need to learn verbal materials in school settings. In learning math facts, for example, the student must associate the problems (7+3= , 5-2= , etc.) with their corresponding answers. In learning to discriminate foreign language words, the learner must associate the foreign word with its English equivalent. Although such tasks are common in elementary school learning, they are perhaps more common in higher education and technological training (Merrill and Salisbury, 1984). Chemistry students must learn the abbreviations of the chemical elements. Medical students learn the names and locations of body parts and piano students learn the position of keys on the keyboard and to associate a particular key with a particular note on the written music. Pairing associations is one way of remembering facts, definitions and formulas when precision is a premium.

Two basic methods of presenting paired-associate lists have been described (Holton and Turnage, 1976). These are referred to as the anticipation method and the recall method. In the anticipation method, the stimulus item is presented alone, followed by presentation of both members of a pair. The task of the subject is to anticipate the response term before the stimulus and response pair are presented together. The recall method of paired-associate learning involves the alternation of study and test trial. During study trials, the entire set of stimulus and response pairs are presented, but no response is required from the subject. After the list has been presented, the test trial requires that subject recall the responses when supplied with corresponding stimuli. This is generally done to a criterion of X number of perfect trials. Analysis is then done by examining the number of trials to criterion and the number of errors made.

The most common type of media research has been the study that compares a specific medium of instruction against one or more other media, often conventional instruction (Wilkerson, 1980). The microcomputer has not been compared to the traditional approach of paired-associate learning. Traditionally, the use of paired-associate learning has been verbal on the part of the learner. Although the drill and practice mode of paired-associate learning seems hardly innovative just to automate on a microcomputer screen, Hall and Loucks (1978) report that the adoption of an innovation is a process, not an event and should be monitored and evaluated periodically. Each new tool in the teaching field encounters a regimen of testing to see if it offers some measurable benefit to teaching and learning.

Stimulus-response, reinforcement and repetition are conditions necessary to the associative learning process. The capabilities of the microcomputer can address these conditions through simple drill and practice procedures and interaction. Virtually no literature links the microcomputer with traditional paired-associate learning.

Findings on paired-associate learning have found learning under the recall method of presentation to be faster than the anticipation method (Battig and Brackett, 1961; Battig and Wu, 1965; Cofer, Diamond, Olsen, Stein and Walker, 1967; Lockhead, 1962). Studies also concluded that repetition of nonsense syllables and trigrams was beneficial to the learning of paired-associates (Rock, 1957; Postman, 1962) and paired-associate lists with rules seem to be superior to lists of unrelated pairs, especially with lists composed of middle-letter changes pairs (Bower and Bolton, 1969; D'Amato and Diamond, 1979; D'Amato and Rubenstein, 1981). In studies that compared the intralist similarity of the trigrams utilized (Underwood, Runquist and Schultz, 1959; Archer, 1960; Horowitz, 1962) contradictory results were reported. While there is evidence that one can learn from media, little evidence is available concerning which medium promotes the most learning in a given situation (Schramm, 1977).

Every medium provides unique learning capabilities (Bork, 1983). The unique feature of the microcomputer is that of interaction. The microcomputer can be programmed to call for repeated input from users and to respond immediately to that input. This basic performance function is called interaction and is performed via the microcomputer keyboard, which has the standard typewriter keys with additional special functions keys.

Although responses are limited to those programmed into the software, this medium allows the user to actively respond instead of passively learning from presented material.

A typical drill and practice microcomputer strategy is similar to the use of flashcards, an activity often employed in the paired-associate learning process. When the learning of lower level skills is necessary, flashcards provide the learner with stimulus on the front of the card and the correct response on the back of the card. The learner responds to each stimulus, presented sequentially, then refers to the response on the back for corrective feedback and perhaps reinforcement. The learner proceeds through the set of flashcards until all items are learned to a desired criterion level. Similarly, the microcomputer can be programmed to provide a stimulus that elicits a response from the learner. It can repeat the same or very similar question until mastery is achieved. The microcomputer can evaluate responses, provide feedback to the learner and repeat the stimulus-response process indefinitely. Unlike the flashcard technique, the microcomputer can automatically analyze the number of errors made and the number of trials to criterion required for completion.

A search of the literature regarding the instructional use of computer-assisted instruction revealed that for the most part, researchers are optimistic about the future of CAI in education. However, in spite of the great potential of computers in education, evidence of success is not conclusive. There exists a degree of consistency concerning favorable attitudes toward CAI and a saving in student time when using computer-assisted instruction (Hall, 1982; Kulik, Kulik, and Cohen, 1980; Kulik, Bangert and Williams, 1983). Consistent findings have also found that CAI is more effective with elementary students than high school students and more effective with high school students than college populations (Jamison, Suppes and Wells, 1974; Hartley, 1977). The whole matter of achievement remains less clear. Findings of "no significant differences" dominate the research in the area of CAI effectiveness of achievement outcomes. Usually CAI has been found to be at least as effective as other forms of traditional instruction and most effective when integrated with classroom teaching (Edwards, Norton, Taylor, Weiss and Dusseldorf, 1975). Most CAI is used to supplement and complement traditional instruction, not replace it, which makes it extremely difficult to compare CAI and traditional instruction.

The purpose of the study was to investigate differences between interactive microcomputer and traditional verbal learning groups in a paired-associate learning task. Due to the complex nature of examining human learning, the dependent variables in the present study were limited to recall performance. Recall was examined in terms of number of correct responses and number of trials to criterion. Intralist similarity, as the independent variable, was examined in terms of high and low associations using CVC (consonant-vowel-consonant) trigrams. CVC trigrams were used to provide a learning situation. In light of the literature, the main expectation was that subjects exposed to the microcomputer treatment would perform significantly better than subjects exposed to the traditional method of verbal learning. It was expected that groups exposed to high similarity lists of CVC trigrams would have higher recall scores than the groups exposed to the low intralist similarity trigrams. It was also expected that number of trials to criterion would be the lowest for learning groups exposed to low similarity CVC trigrams than learning groups given the high similarity trigrams.

Methodology

Subjects

The subjects for the study consisted of eighty-eight (88) male and female undergraduate preservice education students at a large midwestern university. The population included volunteers from an educational technology course which is required of all education students desiring teacher certification in the state.

Assignment of subjects to one of four groups was done on a random basis until twenty-two (22) subjects were obtained in each group. Treatment subjects were selected into appropriate groups by typing skill needed to perform interactive functions on a microcomputer keyboard. Once treatment groups were randomly assigned, high or low similarity lists were randomly assigned to each group.

Procedure

For the basic paired-associate learning task, a high similarity list of ten pairs and a low similarity list of ten pairs were used. Both lists contained ten high frequency words used in a previous study of Horowitz (1962) and matched with either high or low similarity consonant-vowel-consonant (CVC) trigrams. High and low similarity was established by the frequency of repetition of letters and the number of different letters used in the response trigrams. The high response similarity list was composed of five different letters, two vowels and three consonants. The low similarity list was composed of 23 different letters consisting of all vowels and 17 consonants. The CVC trigrams appearing on both high and low similarity lists were matched according to their association value as determined by Archer (1960). The mean association value for the high similarity list was 65.4 and the mean for the low similarity list was 65.5.

Each subject, regardless of treatment or control, participated on an individual basis to learn the list of paired-associated by the recall method. Group 1 was presented a list of ten pairs of high frequency English words matched with high similarity CVC trigrams via an Apple IIe microcomputer screen. Subjects were asked to recall the CVC trigrams by typing responses on the microcomputer keyboard. Group 2 viewed the same ten high frequency English words, but matched with trigrams of low intralist similarity. The list of ten matched pairs was also presented by the Apple IIe microcomputer system and responses typed using the microcomputer keyboard. Groups 3 and 4 were control groups and participated in the traditional approach to paired-associate learning, in which the list of matched pairs was projected via 35mm slides and responses were given verbally. Group 3 was asked to recall ten pairs of high frequency English words matched with high similarity CVC trigrams, as was Group I. However, recall responses were given verbally to the experimenter instead of by typing. Group 4 was presented the same list of English words matched with low similarity trigrams as Group 2. Subjects in Group 4 also responded verbally to the experimenter when recalling CVC trigrams.

Results

The findings reported for this study are the results of testing the hypotheses that provided the foundation for this study. Group means were tested for significance by using 2x2 analysis of variance. Two separate analyses were conducted on the dependent measures, recall and trials to criterion, as each dependent variable was interesting in and of itself. The independent variables of similarity and treatment were contrasted in both measures. The number of correct responses and trials to criterion were measured on microcomputers (interactive) vs. slides (traditional) and on high and low intralist similarity.

The null hypotheses examined were:

Null Hypothesis 1: There are no significant differences between interactive and traditional treatment groups on verbal recall. The analysis of variance for the interactive and traditional treatments found no significant main effect for the two treatments (F=.28, p>.59). There was no significant difference between microcomputer and slides as a treatment on verbal recall. The null hypothesis was retained (see Table 1).

Table 1 goes about here

Table 2 presents the means obtained for recall of CVC trigrams. As the table indicates, the mean number of correctly recalled CVC trigrams was greater for the traditional group than for the interactive group (X=59.01 and 56.14 respectively). However, statistically they were not significant.

Table 2 goes about here

Null Hypothesis 2: There are no significant differences between groups exposed to high similarity lists and groups exposed to low similarity lists on verbal recall. As indicated in Table 1, the similarity dimension was a significant source of variance (F=5.84, p<0.01). The mean scores for high and low similarity (X=63.66 and 51.79 respectively) are shown on Table 2. The groups exposed to lists of CVC trigrams of low similarity performed significantly better on verbal recall. The null hypothesis was rejected.

Null Hypothesis 3: There are no significant differences in interactive vs. traditional groups in total number of trials to criterion. There was no significant main effect for interactive and traditional treatment groups (F=0.21, p>0.64) in total number of trials to criterion (see Table 3).

Table 3 goes about here

The mean scores for interactive vs. traditional groups (X=7.93 and 8.33, respectively) confirm that there was no significant difference between the two groups in the total number of trials to criterion (see Table 4). The null hypothesis was retained.

Null Hypothesis 4: There are no significant differences between groups exposed to high similarity lists and groups exposed to low similarity lists on total number of trials to criterion.

Table 4 goes about here

The analysis of variance found a significant main effect for similarity on total number of trials to criterion (F=5.79, p<0.018). Table 4 indicates the mean score of 7.21 for low similarity groups is significantly lower than the mean score of 9.10 for high similarity groups. The null hypothesis was rejected.

Null Hypothesis 5: There are no significant interactions between groups on similarity and treatment on verbal recall. The two-way interaction between similarity and treatment on recall was not significant (F=0.24, p>0.62). The null hypothesis was retained.

Null Hypothesis 6: There are no significant interactions between groups on similarity and treatment on total number of trials to criterion. The two-way interaction between similarity and treatment on total number of trials to criterion was not significant (F=0.208, p>0.649). The null hypothesis was retained.

Conclusions

Data were analyzed to test for two main effects to determine whether or not there was a significant difference in recall and number of trials to criterion on the independent variables of high and low similarity and interactive and traditional treatment groups.

The following conclusions may be drawn from the results of the data:

1. It was found that subjects exposed to a list of CVC trigrams of low intralist similarity performed significantly better on verbal recall than subjects exposed to a list of high intralist similarity CVC trigrams. Also, the number of trials to criterion was found to be significantly less for the low CVC similarity groups than for the high CVC similarity groups.

2. It was found that neither microcomputer (interactive) nor slides (traditional) showed significantly better results as a treatment on verbal recall and number of trials to criterion in a paired-associate learning task.

Findings and Discussion

The similarity dimension was a significant source of variance in this study. The mean scores for high and low similarity show that treatment groups exposed to a list of CVC trigrams of low similarity performed significantly better on verbal recall. Low intralist similarity groups also took fewer trials to reach criterion than high similarity groups.

This finding adds support to the previous research of Horowitz (1962) who concluded that high intralist similarity hinders associative learning. This study also adds to the data base in the araea of intralist similarity in paired-associate learning, which to date has had contradictory research findings.

It is possible that mnemonics played an important role in learning the list of paired-associates. The high intralist CVC trigrams were so closely matched with only three consonants and two vowels that recall was more difficult even with the use of mnemonic techniques.

Subjects in this study experienced either traditional or interactive techniques of paired-associate learning as treatment. An analysis of variance indicated that there were no significant differences between microcomputer and slides as a treatment on verbal recall and number of trials to criterion when tested at the .05 level of significance.

It should be recognized that all groups were able to learn equally well. No group suffered because of method of treatment to which they were subjected. Even though the difference between microcomputer interaction and traditional treatment groups is not large enough in relation to the validity of the data to be significant, the microcomputer treatment groups performed slightly better than the traditional treatment groups on both verbal recall and number of trials to criterion measures.

A practical value for educators can be found in these results, even if non-significant. Consistent findings of non-significant differences in learning from different instructional mediums provide alternative methods of instruction for the educator. Research has show that no single medium is superior in all aspects in any instructional situation. It is also apparent that any medium can make a viable contribution to almost any learning task. Schramm (1977) in his review of media research literature concluded that:

> Motivated students learn from any medium if it is competently used and adapted to their needs. Within its physical limits, any medium can perform an adequate task. Whether a student learns more from one medium than from another is at least as likely to depend on how the medium is used as on what medium is used. (Schramm, p. iv.)

Another possible explanation for the non-significant finding may be that media and learning are not related to the extent anticipated. If a distinction is made among media, messages, and methods, a medium is merely the vehicle for the information and not the information itself. Therefore, any effect on learning achievement would have to be a result of the message and not the medium.

Computer-assisted instruction can be an effective educational tool under the proper conditions. However, embarrassment, content limitations, feedback, reinforcement and learning styles need to be variables considered in the classroom application of microcomputers and paired-associate verbal learning. Requiring all students to use computer-assisted instruction may not be in the best interests of the student. The matching of the teaching style to a specific computer program and the learning style of the student must be considered.

The research study revealed several areas for further study with microcomputers. First, more studies need to be conducted with the college level population. To date, very few computer-assisted instruction studies have measured achievement of college students on microcomputers. Large mainframe computer studies dominate the literature at this educational level.

A second recommendation is that researchers examine mnemonic techniques as a strategy to help students learn. With the capabilities of graphics, animation, keyboard interaction, color and branching provided by the microcomputer, mnemonics could be programmed into computer-assisted instruction to prompt the subject.

Finally, future studies should incorporate educational theories into the design of computer-assisted instruction. More meaningful content and meaningful applications should be implemented with microcomputers in place of fragmented recall-based lessons. The capabilities of self-pacing, branching, reinforcement and repetition provided by the microcomputer can be utilized in designing computer-assisted instruction with meaningful information in all content areas.

References

Archer, E. (1960). A re-evaluation of the meaningfulnessof all possible CVC trigrams. Psychology Monographs, 74 (10), 1-23.

Battig, W., & Brackett, R. (1961). Comparison of anticipation and recall methods in paired-associate learning. Psychological Reports, 9, 59-65.

Battig, W. F., & Wu, R. D. (1965). Comparison of recall and anticipation paired-associate procedures within mixed aurally-presented lists. Psychonomic Science, 3, 233-234.

Bear, G. B. (1984). Microcomputers and school effectiveness. Educational Technology, 24, (1), 11-15.

Bower, G., & Bolton, L. Why are rhymes easy to learn?. Journal of Experimental Psychology, 82 (3), 453-461.

Bork, A. (1983). Computers and the future: Education. Computers in Education, 8(1), 1-4.

Bugelski, B. (1983). The computer moves in. Time, 121(1), 13-26.

Bugelski, B. (1962). Presentation time, total time and mediation in paired-associate learning. Journal of Experimental Psychology, 63, 409-412.

Bugelski, B., & Rickwood, J. (1963). Presentation time, total time and mediation in paired-associate learning: Self-pacing. Journal of Experimental Psychology, 65, 616-617.

Chambers, J., & Sprecher, W. (1983). Computer-assisted instruction: Its use in the classroom. New Jersey: Prentice-Hall, Inc.

Cofer, C., Diamond, F., Olsen, R., Stein, J., & Walker, H. (1967). Comparison of anticipation and recall methods in paired-associate learning. Journal of Experimental Psychology, 75(4), 545-558.

D'Amato, M., & Diamond, M. (1979). Roles of rules in paired-associate learning. Psychological Reports, 48 (1), 648-650.

D'Amato, M. J., & Rubenstein, V. (1981). Response-set size and paired-associate learning. Psychological Reports, 48(1), 172-174.

Deese, J., & Hulse, S. (1967). The psychology of learning. New York: McGraw Hill.

Edwards, J., Norton, S., Taylor, S., Weiss, M., & Dusseldorf, R. (1975). How effective is CAI -- A review of the research. Educational Leadership, 33 147-153.

Hall. G., & Loucks, S. (1978). Innovation configurations: Analyzing the adaptions of innovations. Procedures for Adopting Educational Innovations, Program Research and Development Center for Teacher Education, The University of Texas at Austin.

Hall, K. A. (1982). Computer-based education. Encyclopedia of Educational Research (5th ed.). New York: Macmillan.

Hartley, S. (1977). Meta-analysis of the effects of individually paced instruction in mathematics. (Doctoral dissertation, University of Colorado, 1977). Dissertation Abstracts

International, 1978, 38(7-A), 4003. (University Microfilms No. 77-29.926.

Holton, D. L., Turnage, T. W. (1976). Human learning. New Jersey: Prentice-Hall, Inc.

Horowitz, L. M. (1962). Associative matching and intralist similarity. Psychological Reports, 10, 751-757.

Jamison, D., Suppes, P., & Wells, S. (1974). Effectiveness of alternative instructional media: A survey. Review of Educational Research, 44, 1-67.

Kolesnik, W. (1976). Learning: educational applications. Boston: Allyn and Bacon, Inc.

Kulik, J., Bangert-Downs, R., & Williams, G. (1983). Effects of computer-based teaching on secondary school students. Journal of Educational Psychology, 75, 19-26.

Kulik, J., Kulik, C., & Cohen, P. (1980). Effectiveness of computer-based college teaching: A meta-analysis of findings. Review of Educational Research, 50, 525-544.

Lockhead, G. R. (1962). Methods of presenting paired associates. Journal of Verbal Learning and Verbal Behavior, 1, 62-65.

Merrill, P., Salisbury, D. (1984). Research on drill and practice strategies. Journal of Computer-Based Instruction, 11(1), 19-21.

Postman, L. (1962). Repetition and paired-associate learning. American Journal of Psychology, 75, 372-389.

Rock, I. (1957). The role of repetition in associative learning. American Journal of Psychology, 70, 186-193.

Saettler, P. (1979). An assessment of the current status of educational technology. ERIC Clearinghouse on Information Resources. Syracuse University.

Schramm, W. (1977). Big media, little media. Beverly Hills, CA: Sage Publications, Inc.

Underwood, B., Runquist, W., & Schultz, R. (1959). Response learning in paired-associate lists as a function of intralist similarity. Journal of Experimental Psychology, 58(1), 70-77.

Wilkerson, G. (1980). Media in instruction: 60 years of research. Washington, DC: Association for Educational Communications and Technology.

Table 1

Analysis of Variance Summary Table

Using Recall of Trigrams

Source of Variance	Sum of Squares	df	Mean Square	F-Ratio
Similarity	2923.64	1	2923.64	5.84*
Medium	141.86	1	141.86	0.28
Similarity X Medium	123.62	1	123.62	0.24
Residual	40048.84	80	500.61	XXX
Total	43270.71	83	521.33	XXX

*p<.05

Table 2

Means for Recall of CVC Trigrams

	High CVC Similarity	Low CVC Similarity	Raw Total
Treatment Microcomputers	$\overline{X}$ = 63.60 SD = 21.93	$\overline{X}$ = 49.36 SD = 19.58	$\overline{X}$ = 56.14
Treatment 35mm Slides	$\overline{X}$ = 63.71 SD = 30.21	$\overline{X}$ = 54.33 SD = 15.17	$\overline{X}$ = 59.02
Column Total	$\overline{X}$ = 63.66 SD = 26.17	$\overline{X}$ = 51.79 SD = 17.54	

Table 3

Analysis of Variance Summary Table Using Number of Trials to Criterion

Source of Variance	Sum of Squares	df	Mean Square	F-Ratio
Similarity	74.11	1	74.11	5.79*
Medium	2.72	1	2.72	0.21
Similarity X Medium	2.66	1	2.66	0.20
Residual	1023.34	80	12.79	XXX
Total	1103.56	83	13.29	XXX

*p<.05

Table 4

Means for Number of Trials to Criterion

	High CVC Similarity	Low CVC Similarity	Raw Total
Treatment Microcomputers	$\overline{X} = 9.10$ SD = 3.61	$\overline{X} = 6.86$ SD = 3.30	$\overline{X} = 7.93$
Treatment 35mm Slides	$\overline{X} = 9.10$ SD = 4.58	$\overline{X} = 7.57$ SD = 2.52	$\overline{X} = 8.33$
Column Total	$\overline{X} = 9.10$ SD = 4.09	$\overline{X} = 7.21$ SD = 2.93	

An Alternative Belief: Negative Aspects of Educational Technology

Randall G. Nichols
625 Teachers College
Department of Curriculum & Instruction
The University of Cincinnati
Cincinnati, Ohio 45221

Running head: NEGATIVE ASPECTS

Abstract

General technology and educational technology are largely parallel in their philosophical-historical development. Today, just as general technology is recognized as having some negative aspects so, too, does educational technology. Some negative aspects of educational technology are explored with regard to their implications in education and society.

An Alternative Belief: Negative Aspects of Educational Technology

Technology has long been recognized as having multiple effects, some of which have been deemed negative. The American government's Office of Technology Assessment is but one outgrowth of that recognition. In contrast, educational technologists apparently have explored technology largely with a view to its positive aspects. Understandably, we believe that technology will better enable us to achieve desired educational outcomes.

The purpose of this paper is to explore the ways in which educational technology and general technology share a common conceptual framework associated with potential and real negative aspects of those technologies. If educational technology is a subset of general technology (Heinich, 1984, p. 67), educational technology also has the potential for various negative consequences. To explore the conceptual similarities and related negative aspects, it will be necessary to explore in light of broad issues. That is, I will look at philosophical and social as well as educational issues.

This exploring is based on two assumptions. First, educational technology and technologists are of a philosophic nature. That is, our development and use of technology and our beliefs about technology are based not only in empirical findings but in logical reasoning, that is, rationalism. I assume, further, that our beliefs also arise from beyond the emirical and rational. That is, what we believe is also based in our intuition, tacit knowledge, and so forth--that which may not necessarily be logical, or at least that which has not yet been understood completely in terms of the empirical and rational.

Let me add that I am aware of most of the positive potentials of educational technology. However, primarily because of my ethical sense, I have chosen to focus here on the negative possibilities. If educational technology has nearly the same negative aspects as technology in general, then I, as an educational technologist, would be remiss in not exploring those aspects.

PHILOSOPHICAL BACKGROUND

There exists a long history of philosophic thought out of which educational technology derives. I believe it is from a brief look at these philosophic concepts that we might best begin to characterize our field with respect to any negative aspects it might hold.

Educational technologists and technology portray a Western philosophic stance. The stance has it origins in Greek thought. For Plato, knowledge of reality comes through the unaided, inner reason of rationalism, while for

Aristotle, knowledge also comes through empiricism, conclusions reached through information about the outside world. From Aristotle we begin to think in terms of cause and effect, and all outside the mind begins to be manipulable. However, both these Greeks remain largely metaphysical. That is, both believe that existence is of a nonmaterial essence that can be described under unifying principles; the world of people and nature is whole.

Berman (1981) has shown that at the end of the Middle Ages, a drastic shift of thinking and belief begins. Bacon (New Organon) argues for a marriage of reason and empiricism in which data about nature reveals truth. Nature is to be manipulated. At about the same time, Descartes (Discourse on Method) expresses the belief that existence outside the mind is too unsure. He exists only to the degree that his mind can clearly and distinctly apply Cartesian method. Essentially then, Descartes' mathematics, so-called pure reason, becomes the instrument for Bacon's empiricism.

As Berman (1981) puts it:

> Finally, atomism, quantifiability, and the deliberate act of viewing nature as an abstraction from which one can distance oneself--all open the possibility that Bacon proclaimed as the true goal of science: control. The Cartesian or technological paragigm is...the equation of truth with utility, with the purposive manipulation of the environment. The holistic view of man as part of nature, as being at home in the cosmos, is so much romantic claptrap. Not holism, but domination of nature; not the ageless rhythm of ecology, but the conscious management of the world... (p. 46).

Metaphysical, mythical, and mysterious conceptions subside. Knowing and existence are believed to be mental, material, and manipulable. The power of the will of the intellect begins emerging as the prominent force of existence. Existence is split into what is classically called "dualism," mind separate from object. I refer to these characteristics and the split as the "mental model."

As part of this conception, Archimedes, Galileo, Copernicus, Kepler, Newton, and many others develop formal notions of science and, with the aid of technology, extend the belief in the mental model. Galileo, for instance, outlines the new science of mechanics. He invents the concepts of perfectly frictionless surfaces and planes of infinite extension. He rolls ball after ball down inclined planes and begins developing the concept of inertia. No matter that, in fact, there never are perfectly frictionless surfaces or infinite planes. The mental conception dominates. Time and space are at our beck and call.

In one view, the mental model and technology first emerge so that we can explain our universe. They are tools for humans. But they quickly become the explanations to which the world conforms, they create our world view. As Kant said, reason becomes "legislative of experience." Or as Berman (1981) observes, "Bacon leaves no doubt that he regards technology as the source of a new epistemology" (p. 30).

In another view, in The Illusion of Technique, Barrett (1979) says that technology is the physical manifestation of this thinking: "Every technique is put to use for some end, and this end is decided in the light of some philosophic outlook or other. The technique cannot produce the philosophy that directs it" (p. 117). He might argue that technology can not legislate experience. Technology is the manifestation of the mental model (p. 202).

The correctness of one view or another is not the point here. What is important is to show that technology is extremely closely related to a mentalistic conception that believes in explaining existence by controllng its material aspects and by separating the mind from the rest of nature.

With the advent of technologies capable of mass production--technologies such as movable type, interchangeable parts, and the telegraph--the mental model of the world is able to predominate on a massive scale. As such, the primary purpose for technology, too, is to explain nature by controlling it. There is, then, a spiraling effect. Technology encourages the mental conception of existence. So the conception grows in pervasiveness. So technology grows. And so on.

Over time, various derivatives of rational and empirical philosophies have been developed, forms of positivism and experimentalism, for instance. Reciprocally, technology has evolved. However, the essential beliefs in control of nature and the separateness of mind from nature remain. What emerges predominantly in the West is the belief in a new reality, where knowledge, truth, and existence itself are equivalent to, or even derivative of, invented intellectual models--logic, science, and technology. Where existence is to be controlled for material gain. Where the mind is believed to be separate from the rest of nature and, perhaps, even from aspects of itself. Where technology may be the model by which we judge existence.

We can hear the essence of this model echoing in American educational thought in John Dewey (Types of Thinking, 1984), for instance, when he says, "the experimental method holds out the only hope of human welfare and progress" (p. 128).

Likewise, we find the mental model, philosophy if you will, very clearly in educational technology. Examine Heinich's (1984) characterization of technology. He first quotes Galbraith (1967): "Technology means the systematic application of scientific and other organized knowledge to practical tasks." He then cites Bell (1973): "the instrumental ordering of human experience within a logic of efficient means, and the direction of nature to use its power for material gain." Of further characteristics that fit educational technology well, Heinich adds: 1. Replicability, with which the goal becomes mass production of necessities for all, and the control shifts from artisans to skilled designers and makers; 2. Reliability, where outcomes are predictable; 3. Algorithmic decision making, wherein technology is decision theory, and decision rules substitute for human judgment. Bell describes this as the dream in which technologists seek reliable replication through "stochastic, probabilistic, and deterministic methods" (pp. 52-53).; 4. Communication and Control, in which instruction is delivered any time, any place, to any one; 5. The Effect of Scale, wherein "sufficient quantitative change causes a qualitative change" (p. 76).

As in its philosophic roots, in educational technology we find a mental conception of the world. We find logic, science, and technology controlling existence for utilitartian and material purposes. All human experience is the object of the intellect. The world of learning is that of mind over experience. The world is split. And fueled by technology, we find the spiraling, where the power, the belief, and the educational technology feed one another and tend toward more and more dominance in education.

EDUCATIONAL TECHNOLOGY AND PHILOSOPHY

Of course, it could be argued that all writing portrays beliefs and, so, is philosophic in nature. However, only a relatively slight amount of the educational technology literature is overtly philosophical (see "BEYOND NARROW CONCEPTIONS" section that follows). Selected examples of that literature bear mentioning.

James D. Finn, perhaps more than any other person, guided the profession of educational technology in the 1950's and 1960's, and for Finn, "philosophizing is an essential component of future planning if we are to go beyond the expedient" (McBeath, 1972). Perhaps Finn's statement from "The Tradition in the Iron Mask" (1961) best indicates his beliefs about educational technology. In defending educational technology against attacks from the literati of the day, Finn wrote that "words alone and the literary sensibility will never solve our serious educational problems. They can help, but our culture is turning--must turn--to technology for this job. Thus, the demands on the audiovisual tradition are great. Realizing this, we certainly do not wish to turn people or schools into automatons and factories. Yet we must wield the technology we are developing to solve the problems of education" (pp. 238-243). Finn's great belief in technology helped the field to move toward a professional status.

Charles Hoban, too, had a great influence on our field. In his last published piece (1977), Hoban warns that without serious consideration of educational technology and values, "unity of purpose in common concerns and broad educational philosophy will remain obscured in rushes of activity without significant action" (p. 239). He deeply senses that our field needed to consider the values we imply. I wonder if the "rushes of activity" he notes refer to computers in education?

Mansfield and Nunan (1978) argue that educational technology represents an ideological position concerned with "knowledge production, transmission, and receival, the basis of which is contained in a belief of the application of explicit and 'rational' processes to problems of human learning" (p. 171). They suggest that the weaknesses in such an ideology include, "the dangers of attempting to reduce all learning to behaviours, the difficulties of achieving precise specification, the unreliability of observation, the distortion of knowledge, the repression of potentially valuable outcomes, the confusion between education and training, the equation of education with evaluation, excessive expenditure of time and resources, and the impossibility of controlling all system variables" (p. 171). They urge the inclusion of philosophy in our instructional development process as a way of ameliorating the dangers.

Jonassen (1984) presents a wholly philosophical analysis and draws conclusions about media and reality, feedback, and intellectual liberation. He points out that, "Since experiencing the mediated event is substantially different from direct experience of an event, the resulting phenomena or conscious perceptions must be substantively different. That's not necessarily bad. In fact, those perceptions are increasingly favored" (p. 166). He goes on to ask, rhetorically, what impact the standardized experiences of mediation might have. This is the kind of question I am addressing here, and I would counter that the impact is bad. The mediated reality emphasizes the distinction between mind and object.

Bork (1986) identifies ethical concerns such as piracy, privacy, equality, and socialization, at least implying that each is threatened by educational computing. On the whole, though, there appears to be little professional discussion about the ethics of educational computing, as Bork says.

Taylor and Johnsen (1986) analyse educational technology in light of its socio-economic, political, and somewhat philosophical characteristics in order to "suggest that the swelling momentum that attends the creation of a new technology in our society in fact works to diminish the potential for human choice and action" (p. 38). In this very thoughtful piece, for one of the few times in our literature that I can find, the authors seriously examine the possibility that our educational technology threatens freedom.

BEYOND NARROW CONCEPTIONS

The preceding not withstanding, it seems to me that, on the whole, educational technologists have taken a predominantly narrow and uncritical view about the effects of our technology. Some of us tend to focus only on media. Also, as Heinich (1984) says, "We have emulated science in our research for too long" (p. 84), and we are "obsessed" with learning gains (p.84). Quite naturally, we tend to focus only on the positive potentials of our technology. Few, if any, of us are taking an overt philosophical perspective. As of October, 1986, only 188 of 7242 documents (.025%) about educational philosophy in ERIC addressed educational technology.

I would argue that the philosophical view associated with educational technology, as outlined herein, is related to various negatve outcomes reported in our current research literature. Most of these outcomes usually are discussed according to our latest theory and research conceptions. However, the following example serves to show that specific negative outcomes can be related more broadly to our belief in the mental-technical model.

For instance, Clark and Salomon (1986) conclude that some symbolic features of media "may actually inhibit learning by preventing the use of previously acquired but more efficient skills that serve the same ends" (p. 469). About these effects, they suggest that, "it should be remembered that Salomon's [Salomon, 1974a] research demonstrates that symbolic features of media can be made to cultivate cognitive effects.... [but] The occurrence of cognitive effects depends on a number of factors including the effort invested, depth of processing, and special aptitudes of individual learners" (p. 469). They recommend, in part, the application of more research techniques to address issues such as the one noted here.

From my point of view though, the inhibition of cognitive skills is associated with a philosophical view. Our beleif in the mental model, including the belief in science and technology, leads inevitably to a separation, or fragmentation, such that even cognitive apects of humans are separated from one another, and so negatively affected. So applying the power and control of more science is not likely to stop the inhibition, or perhaps even atrophy, of cognitive skills, but to exacerbate it.

As indicated earlier, one result of the growth of the mental-technical model is that it tends to concentrate power in few people. I think Heinich (1984) acknowledges this, at least implicitly, when he says, "as technology becomes more powerful and more pervasive in effect, consideration of its use must be raised to higher and higher levels of decision making" (p. 77).

In education, we see this kind of control especially in the instructional development process, where instructional means and methods are determined in nearly every model I've seen by a team of experts. Students do not typically choose the instructional strategies or media, and nowhere do students decide if the goals and objectives meet their own, self-determined purposes. And learning usually is judged ultimately by everyone but the student.

Now if education is construed, at least partially, as student wittingness and voluntariness about means and ends (Peters, 1967), the higher and higher levels of decision-making in much educational technology tend to discourage education. Therefore, the power and control afforded by educational technology can be called negative.

Further, to the degree that our educational technology conception does not fit some more basic, holistic conception of human being and learning, there may be disbelief in some human aspects. For the most part, educational technology encourages the belief that knowing is logical, quantifiable, controllable, and practical. Any learning that cannot be assessed, that does not meet goals made by a social-economic-technical system, that cannot be put into language form, often is ignored or judged as inconsequential.

What aspects are ignored or misjudged? Characterize them as the random aspects of nature, as Bateson (1979) argues. Perhaps they are tacit knowledge, that which we know but can not tell. Or call them intuition. Admittedly, they are difficult to explain because something of what I'm talking about may be inexplicable, at least in terms of language, and different for each person.

One way to characterize the missing aspects is in terms of some metaphysical conceptions, where the world is whole--if not completely rational--and where all of nature interacts with the mind as much as the mind acts upon the rest of nature. Educational technology is not much concerned with "the formation of the broadest and most fundamental characteristics of all experience" (Randall and

Buchler, 1971, p. 308), including, for instance, the aesthetic, moral, or spiritual aspects of humans.

I think we can hear the omission of a metaphysical view in an anecdote. In the spring of 1986, at an informal gathering of professors of instructional technology, I asked Charles Reigeluth about the degree to which we might eventually be able to prescribe "reliable" instruction. He felt we might get to a point where 70% will be reliably prescribed and 30% will be "crafted."

I think that we ignore or, worse, "technologize" that which is in the 30%. Yet because the holistic aspects of existence continue to tug at us, we have a gnawing homelessness, a loss of human spirit. Perhaps it is a too great belief in the mental, scientific, and technical apparatus that has contributed to a large portion of college students being disenchanted with higher education or to many professors continually considering other employment.

Earlier, I mentioned the irony whereby at first we create our technological tools, then they create us. In this way, we actually lose control when we use the mental model of existence, including its manifestation in technology. This notion has been called "autonomous technology."

An example of loss of control lies in the notion of "lifelong education," which has become one of the most predominant concepts of education. From the view I'm giving here, people must continually learn new skills in order to keep up with technological innovations, in order to stay employed, and so that economic institutions can stay on "the cutting edge." In effect therefore, people are conforming to the requisites of the mental-technical model. This may be a profound and even cruel twist in human existence. Whereas technology is thought to serve us, we serve technology.

SOCIAL ASPECTS OF EDUCATIONAL TECHNOLOGY

The philosophic view leads inevitably to questions about the societal ramifications of educational technology.

The theme issue of ECTJ (Kerr and Taylor, 1985) is a recogniton of our social responsibilities. Stewart (p. 58), for instance, argues that educational technology, in several forms and as developed in America, can be inappropriate in developing societies. He points out that, "Most people involved in educational development activity in the Third World are not consciously part of an educational colonialism or educational imperialism, but they are, nevertheless, perpetuating, albeit inadvertently, a cultural bias that is probably inconsistent with the local situation" (p. 62). He wonders if this bias doesn't contribute to "social dislocation" (p. 58).

Stewart reminds us that our world view, philosophy if you will, can lead to negative consequences. However, none of the articles in the theme issue addresses the social concerns from an overtly philosophical view. And most argue for more science and technology. Stewart, in fact, would have us adjust our theory and research along traditional lines (p. 64), adding only the cultural consideration.

But if Taylor and Johnsen (1986) are correct about our illiteracy in the face of technological momentum, and if Holloway (1984) is correct about our adopting, not adapting, technologies from socio-economic interests, and if Heinich (1984) is correct about our needing to look at general technology, then we must begin to examine more assiduously any negative societal aspects of our technology.

In this section, I am labeling a variety of concepts as "societal." Economic, political, and military institutions; environmental issues; human resources agencies; and so on are grouped under this heading. I do this for the sake of convenience, admittedly, and given that I simply want to suggest some ways that educational technology and social entities are conceptually closely related with respect to negative consequences.

In many cases, the social relationship is not very direct, discernable, or apparently dramatic. However, the connection is not lost if we remember that educational technology is a subset of general technology, and if we first survey some negative effects of general technology.

The belief in, power of, and spiraling effects of technology are evident in a concept referred to as the "technological fix." When we get into perceivably dangerous circumstances with our technology, we apply more technology. The technological fix, however, very often does not work. Examine a typical application and development of general technology. Two hundred years ago, flooding on the Mississippi River caused relatively few lives and livelihoods to be threatened. Early attempts at flood control on parts of the Mississippi created slightly greater flooding and human distress elsewhere along the river. More lately, large-scale technologies have been used to levee, dam, and lock nearly the entire length of the river. Consequently, changed hydrology and silting are causing New Orleans to sink. At the same time, the controlled Mississippi flows more powerfully through its channel. A dam above New Orleans is in constant danger of bursting because of the power. If it bursts, millions of lives are threatened, both from the deluge of water and from a wrecked economy across America and the world (WTTW and BBC, 1986).

Our attempts at controlling nature have led to some obvious threats to the environment. General technology is helping to create a degenerating earth environment of amazing proportions. For instance, our technologies have enabled us to begin deforestation of the Amazon River Basin. I must wonder if we will have to look for ways to stop the devastation of the forest which provides one third of the earth's oxygen.

The idea that we should control nature extends to control of ourselves as well, and the most immediately troublesome consequences in this area may be economic. In The New American Poverty, Harrington (1984) has shown that, in part, technology and the people who control it are causing massive, negative social changes. Technology is helping to create a huge number of menial service jobs, an enlarging class of "working poor," and swelling unemployment and homelessness. At one point, Harrington addresses issues raised by Nobel laureate Wassily Leontiev. Harrington says:

> Until recently, Leontiev argued, capitalism has been creating its own markets, since the technology of its success has required more and more skilled workers. But now the technological revolution is changing all that. Just as tractors replaced farm horses...so computerized production is replacing human beings.
> This means...not only technological unemployment but a basic shift in the distribution of income and wealth, a more polarized society with a well-paid elite and a poorly paid mass (p. 237).

Harrington adds that, "it is precisely this trend that now makes the sweatshop viable in the United States. A very low technology and a very high technology become profitable at the same time because the middle is beginning to disappear" (p. 238).

Correlatively, family structures are changing. In most two-parent families, both parents work. Latch-key children are common. In turn, social agencies need to grow out of or enlarge because of people's needs for housing, employment, and health and child care.

The most obvious negative manifestation of technology may be related to people's health. Direct, human physical damage is associated with technology. An estimated 500 million people a day around the world are hungry and dying. Around the world, the largest migration of people in history is occurring now. These consequences are attributable in large measure to technology and the profit motive of those who control it (Richter, 1985). We see, again, the separateness technology fosters. Technology is wrenching people from their homes.

But the dualism, the separateness associated with the mental conception and technology, leads to a psychic homelessness, too. The psychological stress created by some of these changes in family structure, employment, and residence is well known. Depression related to these changes is showing a marked increase (Depression, 1986). The belief that the mind is separate from self and the rest of nature, and the resulting psychic homelessness, may be manifested in the increased psychosis, for instance, that in our era is higher than in others, except for those periods in history where rapid changes occurred (Berman, 1981, p. 22). There is a crisis in self, a crisis of spirit and being.

The connection between educational technology, general technology, and negative societal consequences is not lost if we remember again that, in many of its basic features, educational technology is analogus to general technology. The connection is especially clear in that our generally positive beliefs about educational technology foster a belief and proliferation in general technology. We contribute to what Taylor and Johnsen (1986) have called the "technological momentum."

The relationship of educational technology to societal entities exists directly in some ways. For instance, many of our graduates go to work outside education (Marcyes, 1984) and, conversely, the results of our research in instructional development, for instance, affect the ways the private sector trains employees.

Also, educational technologists very often react to social imperatives of various sorts, especially the imperative to buy hardware. Holloway (1984), argues that we adopt rather than adapt or create our own educational hardware. I must wonder, therefore, how "witting and voluntary" we educational technologists are about purchases. To the degree that our purchases are less a professionally conceived activity attending primarily to education, and more a social imperative connected to economic, political, or military gain, our buying hardware can be called a negative consequence of the mental model and technology.

Our reaction to the military may be particularly disturbing. As even a cursory reading of Saettler's (1968) history shows, the relationship is a long and close one. Still today, we send people and technologies to the military, one of whose functions, to put it bluntly, is to kill people. One could argue, therefore, that educational technology is being used to kill people.

Many of these issues come together very obviously when we consider our purchases of computers. The manufacture of computer chips produces toxic by-products that contaminate the environment and cause sickness in workers at production facilities. Therefore, our purchase and use of computers for education threatens people's health. I am being only partly facetious when I say that many of the papers at this conference, mine included, may make people ill.

Social entities, including education and educational technology, combine to form a complex web of interactions in which determining motives, responsibility, and the exact nature of the interactions is very difficult. However, technology and the people and social institutions that use technology have combined to put the world and its people in peril. To the degree that educational technologists and technology interact with those social entities and technologies, they may be culpable for this peril.

EDUCATIONAL TECHNOLOGY AND FREEDOM

We may ultimately view the foregoing issues as issues of freedom. As Barrett (1979) says with respect to technology, "The question for our generation...is whether or not mankind will decide for liberty or sink under some modern form of tyranny" (p. 246). To the degree that our use of technology might control students rather than free their choices, and to the degree that students are illiterate about technology, as is indicated by The Carnegie Commission on Education (Boyer, 1983), educational technology may be construed as tyrannical.

Educational technology and technologists may contribute to any tyranny because we are apparently not obviously interested in the sorts of issues I've been raising. Of the 941 faculty who describe their primary interests in Masters Curricula in Educational Communications and Technology: a Descriptive Directory (Johnson, 1985), only five faculty are interested in social issues, and only two are interested in cultural issues. And I remind you of the few authors who are not apparently interested in philosophical issues related to educational technology.

THE FUTURE

Of the many possible future forms of educational technology, one in particular leads me to believe that the future may be more perilous than it is now. I conceive of this form as educational biotechnology (EBT). EBT is the study and application of scientific and other organized knowledge, processes, and products to the physical state of humans for the purpose of creating changes in all aspects of learning. The key characteristic is physical invasion of the body, though psychological changes certainly occur also. Surgery on, the connecting of machines to, or the giving of food, drugs, and chemicals to people so their educational lives are changed are educational biotechnologies. For instance, Gnirk and Gustafson (1986) report on the use of computers and EEG's and speculate that, "Perhaps in the future this could be monitored so that when a learner's attention begins to wander, a switch could be triggered and the student's attention brought back to instruction" (p. 242).

The issues of control, separation, and socio-economic imperative seem obvious to me in EBT. Most importantly, ethical issues about the many potential dangers of such physical manipulation begin to glare. When the body is invaded for health purposes, the technology may be ethical. But invasion for the purpose of creating an "educated" person might, at best, be called "cosmetic."

EDUCATIONAL TECHNOLOGY NEED NOT BE DETERMINISTIC

Admittedly, I have taken a rather one-sided position: educational technology is really and potentially harmful. I have done this partly because educational technologists apparently are not interested in considering the harm in any formal, widespread way. Primarily though, I think technology and educational technology are associated with such dramatic negative possibilities that positive potentials may matter little. There comes a time when to point almost wholly to the positive aspects of technology may be morally indefensible.

But I do not think all is hopeless. Technology need not be deterministic. Some of the works cited earlier (Heinich, 1984; Taylor and Johnsen, 1986; Bork, 1986; Jonassen, 1984) are encouraging. Fosnot's (1984) constructivist view reminds us of our connections to philosophy and encourages us to consider the notion of controlling students. She concludes that, "If learning is understood as a series of constructions that depend on the learner's structures and schemes, then the educator must be willing to give up control and allow self-regulation to occur" (p. 203).

In "The Question Concerning Technology," philosopher Martin Heidegger (1977) offers a bright possibility when he says that, "it is precisely in this extreme danger that the innermost indestructible belongingness of man...may come to light, provided that we, for our part, begin to pay heed to the coming of presence of technology" (p. 32). "Because the essence of technology is nothing technological, essential reflection upon technology and decisive confrontation with it must happen in a realm that is, on one hand, akin to the essence of technology and, on the other, fundamentally different from it" (p. 35). He suggests that that difference lies in something like art.

RECOMMENDATIONS

In preparing this paper, I called AECT headquarters to ask if a written philosophy of our field exists. I was referred to the Human Resources Directory, the top section, where we are told that AECT: is dedicated to the development and use of technology and media; campaigns at state and federal levels for resources; provides a clearinghouse for ideas; and has members who pioneer in the use of technology for improved education and who recognize the "importance of the technological revolution in education and training" (p. 3).

In a lay sense, we can glean from these statements the philosophy that pervades our profession, at least as one of our professional associations sees it. The zeal implied by the use of "revolution" may be particularly indicative of our beliefs about technology. But in an academic sense, it seems to me that this association does not have a well-stated philosophy. First, there is no extended analytical statement of a belief about the relation of technology to a meaningful and significant life, including educational aspects of life. Secondly, there is no extended analytical discussion of the philosophic processes we employ. Accordingly, I recommend that we study and make explicit the current philosophy under which our research, theory, and practice operate. I recommend the same for a philosophy under which we might operate.

Though I hope that one outcome of this paper has been to show a need to investigate philosophic matters, I have not intended, necessarily, to offer a philosophic alternative. However, I do suggest that a more purely mental-technical philosophy, including the "technological fix," is not likely to suffice. Instead, we could investigate relativism or constructivism more closely. Even existential, metaphysical, and Eastern philosophies offer viable alternatives.

Given the impending proliferation of EBT and the like, I recommend that consideration of ethics be given highest priority. When biological and educational technologies meet as they can, the ethical questions are at least as dramatic as those currently seen in medicine. Beyond most conceptions of ethics in our field, which deal predominantly with how to insure privacy, ownership, or equality, we should primaily be asking if various educational technologies are ethical and whether or not they should be encouraged at all. Clark and Salomon (p. 475, 1986) make essentially the same point. Similarly, we should examine our ethics with respect to social issues, especially the threat to the earth's ecology.

Our research might begin tracking negative aspects of educational technology just as the American government has with the Office of Technology Assessment. We might have an Office of Educational Technology Assessment (OETA). I would caution that OETA not be wholly technological in terms of its philosophy.

If, as Barrett (1979) says, "every technique is put to use for some end," we should make assessments that ask about ultimate purposes. These are the purposes beyond instructional objectives. We ("we" especially includes students) must observe an instance of educational technology and ask why it exists. If we find that it is primarily for economic, political, or military, purposes, for instance, we must judge these purposes against a conception of an "educated" person. If we find the educational technology is more in response to a "technological imperative" than to education, judge this response. If we find that educational technology opens us to holistic conceptions of the world, judge this. Then ask again about purposes. I believe that inquiry about the ultimate purposes of technology fosters learners and education professionals who are literate about technology.

CONCLUSION

I am certain that reactions to what I have presented are mixed. My view may run contrary to predominant conceptions and aspirations of the field of educational technology. I have not always presented "hard data" but rather philosophical analysis and speculation. I suspect that the philosophy has been too sketchy. Regardless, I hope that what may be a distant chord has been struck in some of you, a chord that helps you to wonder about the nature of educational technology and its meaning to human existence beyond the hardware, the classroom, and even the mind.

As Heidegger has said, "For questioning is the piety of thought" (p. 35).

REFERENCES

Bacon, F. New organon, Book I. In Hugh G. Dick (Ed.), Selected writings of Francis Bacon. New York: The Modern Library. (1955).

Barrett, W. (1979). The illusion of technique. Garden City, New York: Anchor Books.

Bateson, G. (1979). Mind and nature. Toronto: Bantam Books.

Bell, D. (1973). Technology, nature and society. In Technology and the frontier of knowledge. Garden City, New York: Doubleday.

Berman, M. (1981). The reenchantment of the world. Ithaca, New York: Cornell University Press.

Bork, A. (1986). Ethical issues associated with the use of computers in learning environments. Unpublished manuscript.

Boyer, E. L. (1983). High school: A report on secondary education in America. (The Carnegie Foundation for the Advancement of Teaching) New York: Harper and Row.

Clark, R. E. & Salomon, G. (1986). Media in teaching. In M. C. Wittrock (Ed.), Handbook of research on teaching (pp. 464-478). New York: Macmillan.

Depression incidence spiraling upward. (1986, October). Internal Medicine News, 19, (2), pp. 3-28.

Descarte, R. Discourse on Method. (L. J. Lafleur, Trans.). Indianapolis: The Liberal Arts Press. (1950, original French edition, 1637).

Dewey, J. (1984). Types of thinking. New York: Philosophical Library.

Finn, J. D. (1961). The tradition in the iron mask. Audiovisual Instruction, 6, 238-243.

Fosnot, C. T. (1984). Media and technology in education: A constructivist view. Educational Communication and Technology Journal, 32, 195-205.

Galbraith, J. K. (1967). The new industrial state. Boston: Houghton Mifflin.

Gnirk, F. G. & Gustafson, K. L. (1986). Instructional technology. New York: Holt, Rinehart and Winston.

Harrington, M. (1984). The new American poverty. New York: **Penguin Books.**

Heidegger, M. (1977). The question concerning technology. In The question concerning technology and other essays. New York: Harper and Row.

Heinich, R. (1984). The proper study of instructional technology. Educational Communication and Technology Journal, 32, 67-88.

Hoban, C. F. (1977). Educational technology and human values. Audio Visual Communication Review, 25, 221-241.

Holloway, R. E. (1984). Educational technology: A critical perspective. Syracuse University: ERIC Clearinghouse on Information Resources.

Johnson, J. K. (Ed.). (1985). Masters curricula in educational communications and technology: A descriptive directory. Washington, D.C.: Association for Educational Communications and Technology.

Jonassen, D. H. (1984). The mediation of experience and educational technology: A philosophical analysis. Educational Communication and Technology Journal, 32, 153-167.

Kerr, S. T. & Taylor, W. D. (Eds.). (1985). Theme issue: Social aspects of educational communication and technology. Educational Communication and Technology Journal. 33(1).

Mansfield, R. & Nunan, E. E. (1978). Towards an alternative educational technology. British Journal of Educational Technology: Journal of the Council for Educational Technology, 9, 170-6.

Marcyes, D. D. (1984). Employment trends for media graduates (1982-83): The computer is here. In J. W. Brown & S. N. Brown (Eds.), Educational media yearbook 1984 (pp. 104-110). New York: R. W. Bowker.

McBeath, R. J. (Ed.). (1972). Extending Education through technology. Selected writings by James D. finn on instructional technology. Washington, D, C.: Association for educational communications and technology.

Peters, R. S. (1967). Ethics and education. Atlanta: Scott, Foresman and Company.

Randall, J. H. & Buchler, J. (1971). Philosophy: An **introduction**. New York: Barnes and Noble.

Richter, R. (Producer). (1985). Hungry for Profit [Film]. New York: Robert Richter Productions & The Television Laboratory at WNET/Thirteen.

Saettler, P. (1968). A history of instructional technology. New York: McGraw-Hill.

Salomon, G. (1974a). Internalization of filmic schematic operations in interaction with learners' aptitudes. Journal of Educational Psychology, 66, 499-511.

Stewart, A. (1985). Appropriate educational technology: Does 'appropriateness' have implications for the theoretical framework of educational technology?" Educational Communication and Technology Journal, 33, 58-65.

Taylor, W.D. & Johnsen, J.B. (1986). Resisting technological momentum. In J.A. Culbertson & L.L. Cunningham (Eds.), Technology and education (85th Yearbook of the National Society for the Study of Education). Chicago: University of Chicago Press.

WTTW & BBC. (Producers). (1986). The Great River [Film]. Chicago: WTTW & BBC.

Prospectus for New Directions in Educational Film Research

Daniel J. Perkins

Department of Communication Arts

University of Wisconsin - Eau Claire

"Prospectus for New Directions in Educational Film Research."

My involvement in this panel is intended as a means of indicating how additional film/video materials and how other methodologies might suggest possibilities for further research.

During the past five years I have engaged in attempting to discover why film history and film theory have taken the course they have. That is, my basic premise was related to searching through contemporary books on film history or film theory and noting the rationale for including particular films (especially those from Hollywood) and excluding others films; e.g. educational and corporate.

During this search, I noted that most of the rationale provided in these books revolved around recurring themes. Themes such as 1) "the bigger the better," i.e. indicating that the more money spent on a film, the more the film deserved to be included and discussed (Jacobs, 1967; Mast, 1976; Monaco, 1979; Sklar, 1975); 2) audience attendance -- the larger the audience, the more the film is worth discussing (Ellis, 1979; Jacobs, 1967; Sklar, 1975); 3) the number of films produced by a company, during a particular year, etc. (Ellis, 1979; Jacobs, 1967; Mast, 1976; Monaco, 1979); 4) the potential "effect" of a film or films in general (e.g. Sklar, 1975); 5) auteurism -- i.e. the assumption that to be able to categorize a director's works by identifying the director's style is to insinuate some importance to both the director and the works themselves (Ellis, 1979; Fell, 1979; Sarris, 1968); 6) genre -- the ability to categorize films into various groupings as a measure of the viability of that film type (Solomon, 1976); and 7) the number of bookings a film receives during a particular period suggested as a measure of the value of the film (Monaco, 1979). These are not the only approaches. However, they tend to be those which occur most often.

I am not suggesting that these approaches to writing film history and theory are not important. Rather, that these approaches have been applied almost exclusively to the traditional Hollywood film and the surrounding production circumstance. My assumption has been that to be a viable historical or theoretical methodology, the methodology should be applicable to all films. Taking that assumption in hand, I began to research a particular category of film -- a category as defined by those producing such films as the sponsored or corporate film.

What I discovered was that the arguments set forth for the Hollywood film, applied quite directly to the corporate product. What I noted was that during many years, and cited as early as 1909 in the trade paper Nickelodeon, the average amount of money spent on a Hollywood film was very close to the average amount spent on comparable corporate products. Additionally, through other early papers and magazines such as Motography, Scientific American, Iron Age, Printers Ink Monthly, Electric World, Advertising and Selling, and (most importantly) Business Screen, I noted that these corporate films drew audiences of a size similar to the Hollywood film audience, that there were a prodigious number of these films being made each year, that there had been thorough and substantive audience effects studies performed on many of these films, that there was a track record of producing these films by particular filmmakers -- often filmmakers who were to later become important in the Hollywood scene started in corporate film production -- and that the corporate filmmakers also developed particular categories for classifying their films.

My tentative conclusions revolved around the position that if one could apply the same rationale to these corporate products as to the well touted Hollywood products, and if the rationale held-up, why then was did there seem to be so little research being done on these corporate films?

That there is little being done in the realm of analyzing this particular non-Hollywood product is reflected quite strongly in this bibliography I have compiled. I surveyed the theses and dissertations lists published by Ray Fielding -- lists which indicate the inclusion of nearly 3,000 foreign and domestic theses and dissertations on film and video from 1916-present. From those lists I was able to locate merely 21 works which include any discussion of corporate or sponsored films. So, additionally, I did a key word computer search through my university library and located only 16 more articles on the subject.

Quite apparently this is a body of films which stands relatively untapped, ready for investigation by both the scholars and the many graduate students in your ranks. And, if, as Thomas Hope reports in his corporate film/video newsletter, this year alone, there will be produced some 9,000 corporate films and some 36,000 corporate videos, and that production of this volume has been on-going for many, many years, there is an incredible amount of work to be done.

Additionally, I would suggest that there is a need for developing greater synthesis between established theoretical approaches from within *your* ranks, and the traditional historical and theoretical approaches recently developed in cinema studies. For example, in the first edition of Fielding's collection of theses and dissertations there are listed some 466 titles related in some way to the "Educational and Instructional Film: Research and Application". Of these titles, nearly all read in similar fashion to "The effect on selected science objectives of a sound motion picture with accompanying classroom teaching" and "The comparative effectiveness of a wall model, motion picture films, film strips and the standard slide rule." Of these 466 dissertations, *one* suggests a syntheses between extant film theory and educational films: to wit: "Critical Methodology and Film Education." These papers presented on the panel today are indeed exceptions to the norm.

It is not my intent to insinuate that the traditional approaches of your discipline are in any way less than viable. What I would suggest is that there is a body of information -- theses and dissertations alone reaching some 3,000 -- which might provide interesting and substantive bases for syntheses of ideas between extant, and now accepted film theory and history, and the traditional approaches and concerns stemming from the many years of developing pedagogical theory.

To date, I have been able to interest few scholars in the merit of studying corporate films or in pursuing a synthesis of pedagogical research and the traditional film theory or historical methodologies. As reflected in my bibliography I have located only 11 scholarly papers on the subject, three of those were presented here today.

What I am suggesting is that, possibly, members of this orgainzation may begin by accessing and discussing this large but relatively untapped body of films and video tapes in the corporate field.

Who better? The corporate product is most often easily categorized in an educational mode. Training films must be structured with pedagogical ends in mind. Those products listed in the Manufacturing or Research and Development categories certainly demand careful pre-post analysis. Even those film/video products in the Sales, Marketing or External Communications areas have as their basic tenets the need to establish careful behavioral objectives before they are produced. Additionally, with the corporate tendency to use interactive video-disk systems (and the number of panels on video-disk at this conference), it would seem profitable to ask questions of the corporate media which are already being asked of similar media as it is used in more purely educational situations.

More importantly is the issue that many of these corporate/sponsored products find their way into our vision -- via fill on cable channels, or as part of regular programming on public access channels. Some are even finding their way to home vcr's. For example, General Dynamics in Dallas notes an expanding video lending library and a present lending rate of company videos at 650 per month. Even in my city of Eau Claire Wisconsin, Northern States Power is establishing a video lending library for its employees -- a library of tapes related directly to the business.

Why are such corporate lending libraries important? Almost weekly now-a-days we hear some concern voiced about what Hollywood films and network television programs are teaching our children. At least we are aware of those products. But what of the thousands of corporate products made each year -- many of which are sent *gratis* to our schools. Do we necessarily want our children being told by General Motors, under the guise of a film which purports to be about a group of young rock musicians, that the profit motive is the all-important dynamic which drives our country? Or what about the people working for Hughes Aircraft, people who may view a company sponsored film during their lunch hour. What is the possible effect on them as they passively receive information about those political candidates Hughes Aircraft wants elected?

My point is that there are many thousands of film/video products being produced companies and screened both by company employees and school children. Many products about which few people have even begun to ask questions. The Society for Cinema Studies has provided open discussion on these films for two hours only, the University Film/Video Association allotted a full day at a recent annual meeting -- attendance was sparce. Overall, they seem not to care. It is the Hollywood product which is the gleam in the eye of those organizations.

I think it is this your organization which is in the position of making the breakthrough in the study of these films. You have the strength of numbers and, more importantly, most of these film/videos fall within the perview of the sorts of questions you can and do regularly ask. Questions reflected in the recent, and I think, incisive article by Stephen Kerr (1985). He asks: "What are the roll and status of educational technologists in schools and colleges, corporations, the military, and other work environments" (p. 13)? As an outsider, I would suggest that first and foremost it is to ask questions. But into Kerr's analysis might be placed such concerns as; How have lines of communication changed within bureauacracies with incoming new technologies? What is the roll of film/video in those lines of communication? What are the uses and potential effects on the users of these corporate products?

Where might one begin? Presently the major source for such materials is through the American Archives of the Factual Film at Iowa State University. The facility has been there many years, but few scholars, even scholars on that campus, have taken advantage of accessing the 6-10 thousand films in the collection. Films from businesses, corporations, and educational facilities. Available brochures and catalogs can provide those of you who are interested some information regarding the facility and its function. To obtain copies, you might simply write to: Dr. Stanley Yates, AAFF, University Library, Iowa State University, Ames, IA 50011.

Unlike the other organizations which could pursue such questions, yours has both the strength of numbers and the history of synthesizing ideas and approaches which could develop some new, intreguing and exciting possibilities for scholarly discovery. I urge you to begin to follow the lead of your colleagues on this panel and to, at least, consider some of the possibilities.

REFERENCE LIST

Ellis, Jack C.(1979). *A History of Film*. Madison: University of Wisconsin Press,

Fell, John L.(1979). *A History of Films*. New York: Prentice-Hall.

Jacobs, Lewis.(1967). *The Rise of The American Film*. New York: Teachers College Press.

Kerr, Stephen T.(1985). "Introduction: Asking New Questions About Technology and the Social World of Education." *ECTJ*, 33(1), 4-8.

Mast, Gerald.(1976). *A Short History of the Movies*. Indianapolis: Bobbs-Merrill.

Monaco, James.(1979). *American Film Now*. New York: American Library.

Sarris, Andrew.(1969). *The American Cinema*. New York: E.P. Dutton.

Sklar, Robert.(1975). *Movie-Made America*. New York: Random House.

Solomon, Stanley.(1976). *Beyond Formula: American Film Genres*. New York: Harcourt Brace Jovanovich.

THE EFFECTS OF PRACTICE AND ORIENTING ACTIVITIES ON LEARNING FROM INTERACTIVE VIDEO

Timothy L. Phillips, Michael J. Hannafin, and Steven D. Tripp
Center for Research and Development in Education Computing
176 Chambers
The Pennsylvania State University
University Park, PA 16802

Running Head: Levels of Practice
Submission Date: October 17, 1986

ABSTRACT

The purpose of this study was to examine the combined effects of orienting activities and levels of practice on learning from interactive video. Participants were 72 college students. Each participant was randomly assigned to either a group that received an orienting activity or one that did not. Students were further assigned to one of three practice groups: No Practice, Limited Practice, or Elaborate Practice. An interactive video lesson, focusing on characteristics of various artists and art periods, was then presented. The lesson included interaction in the form of criterion-based practice for one-half of the facts and applications cued initially via the orienting activity. Results indicated significant effects in favor of embedded practice versus no practice. Results also indicated that there were no significant differences between limited practice and elaborate practice for recall of lesson information.

THE EFFECTS OF LEVELS OF PRACTICE AND ORIENTING ACTIVITIES ON LEARNING FROM INTERACTIVE VIDEO

The application of interactive video as an instructional medium has been the focus of growing interest during the past few years (Brawley & Peterson, 1983). Until recently, however, empirical research on the effects of interactive video has been sparse (Hannafin, 1985; Hannafin, Garhart, Rieber, & Phillips, 1985).

One current area of interest in the design of interactive video is the effect of orienting activities on learning (Hannafin & Phillips, 1986). Orienting activities are mediators through which subsequent instruction can be presented (Hannafin & Hughes, 1986). Results of studies on the effects of orienting activities during interactive video indicate that both the amount and type of learning can be effected. However, the effectiveness of orienting activities tends to be inversely related to lesson organization (Ausubel, 1978; Mayer, 1979). The power of orienting activities increases as the availability of alternative processing aids, such as practice, decreases.

Practice, another area of interest in the design of computer-based instruction (CBE), in certain learning situations, has been found to be an effective aid to learner processing (Salisbury, Richards, & Klein, 1985). One common form of practice is the use of embedded questions. Adjunct questions, depending in part on the specificity of the query, influence what is learned (Wager & Wager, 1985; Hamaker, 1986). Factually explicit questions, for example, typically require the learner to recall or recognize information exactly as presented during the lesson. This type of question may improve the learning of factual information but limit the learning of high level information (Clark, 1984). Higher order questions require the learner to reformulate material previously presented with new information (Andre, 1979), and have often been found to have a postive effect on the learning of factual information.

The type of feedback provided during practice can also effect learning. Elaborate forms of feedback, those providing detailed information related to student responses, have proven effective during interactive video. Schaffer and Hannafin (1986), for example, employed progressively elaborate forms of feedback to learners during an interactive video lesson and reported increased overall learning but reduced efficiency. However, increases in the complexity of feedback do not always increase learning. Rather, in certain situations, less elaborate forms of feedback have been found to be most effective (Kulhavy, White, Top, Chan, & Adams, 1985).

Recent research has suggested that the effectiveness of learning variables, such as embedded orienting activities and learning strategies, are often subsumed by en-route practice. However, practice has often been treated as a within-subject factor, potentially confounding the effects of the remaining variables. The purpose of this study was to examine the effect of varied levels of practice and orienting activities on the learning of facts and applications. Unlike earlier research, practice was treated as a between-subjects factor in the present study.

METHODS

Subjects

Subjects consisted of 72 volunteer undergraduate students enrolled in an introductory educational psychology course. Students received extra credit for participation in the study.

Materials

Lesson Content.

The lesson content was adapted from a portion of the National Gallery of Art videodisc entitled "Tour of the National Gallery of Art". It presented information about artistic styles, individual artists, and the effects of historical events on the artistic periods. Each artistic period is explained and the characteristics and famous artists of the era are highlighted.

The lesson was designed to present factual information and to teach participants to apply the knowledge. Factual information included names of artists, geographic locations, social and political factors effecting the art of a period, and the names of the different artistic eras. On the other hand, applications included the characteristics of the paintings of individual artists and each of the artistic eras. This knowledge could then be applied to classify various works according to artist or era.

Instructional Segments.

The lesson consisted of eight video segments, which covered chronologically the artistic periods from the late 13th century to the 20th century. Information in each segment dealt with social and political influences, noteworthy artists, and characteristics or style of the art of that period. Each of the segments was roughly 3-5 minutes in length and contained approximately the same amount of information. All participants received the same information in the same sequence: an orienting activity, information presentation, practice, and feedback. The lesson required approximately 50 minutes to complete.

Orienting Activity.

Prior to each instructional segment, one-half of the subjects were presented with an orienting activity. The orienting activity included a brief statement designed to assist learners to prepare for the information to come, prior to each instructional segment. An example of an orienting activity was: "In this section, pay attention to information concerning the dominating influences that affected art in the 14th century." The remaining subjects did not receive an orienting activity. Instead, these participants were given the following information prior to the instructional segment: "Use whatever way you remember and learn most effectively to prepare for the next section." All subjects were given 10 seconds to process the orienting activity prior to beginning the instructional segment.

Practice Questions and Feedback.

Practice was provided as an opportunity to answer questions related to the information presented. Two types of questions, factual and application, were utilized. Factual questions dealt with the declarative,historical information about artists, countries, and political factors. Application questions provided practice in identifying characteristics of artists or the art of a period. During application questions, students were presented previously unseen paintings and asked to identify the period in which it was painted (or the artist) based upon the characteristics of the painting.

Three levels of practice were utilized in this study: Elaborate Practice, Limited Practice, and No Practice.

Elaborate Practice. Subjects in the elaborate practice group received two multiple choice questions (1 fact, 1 application) after each of the eight instructional segments. Following each of the questions, students received appropriate feedback based upon the correctness of their answer (e.g., "Very Good, that was correct"; "Sorry, that's not right"). Students who initially answered incorrectly were told to pay closer attention as a relevant portion of the video was replayed. If answered incorrectly on the second attempt the correct answer was provided and the lesson continued.

Limited Practice. Subjects in the limited practice group received the same two multiple choice questions (1 fact, 1 application) following each of the eight instructional segments. Following each of the questions, students received appropriate feedback based upon the correctness of their answer. Students answering incorrectly were provided with the correct answer to the question before the lesson continued.

No Practice. The lesson presented to this group contained no embedded questions, but contained the same lesson sequence and flow as the other levels.

Lesson Posttest.

The posttest consisted of 32 five-part multiple choice questions: 16 questions (8 fact, 8 application) were repeated from the embedded portion of the test; the remaining 16 questions (8 fact, 8 application) were parallel in nature and equivalent in difficulty but not previously practiced. All questions tested information presented in the lesson. Reliability of the overall posttest was also computed (alpha = .77).

Design and Data Analysis

The study employed a 2x3 between subject design with two additional completely crossed within-subjects factors. The between subjects factors were Orienting Activity (Activity, No Activity) and Level of Practice(Elaborate Practice, Limited Practice, and No Practice). The within subject factors were Type of Learning (Facts and Applications) and Question Familiarity (New, Repeated). MANOVA procedures were used to analyze overall effects, with follow-up ANOVA procedures to test for univariate effects.

Procedures

Subjects were randomly assigned to one of the six groups. Prior to beginning the study, a brief orientation to the equipment and the nature of the study was provided. The instructional portion of the treatment and the posttest were administered consecutively during the session in accordance with treatment group assignments. All subjects were administered the lesson in noise-proof cubicles which were reserved for this study. Participants were provided with general information regarding their performance upon completion of the posttest.

RESULTS AND DISCUSSION

The mean number of correct responses for each posttest subscale were computed for each student. Since no effects involving orienting activities were found, the means and standard deviations, collapsed across Orienting Activities, are shown on Table 1. As expected, significant overall effects were found for Practice, $F(2,66) = 25.60$, $p<.0001$. As indicated by the interaction between Practice and Type of Learning, the effects of practice were the same for both Facts and Applications, but proportionally greater for Facts, $F(2,66) = 4.45$, $p = .015$. This interaction is illustrated in Figure 1. There was virtually no difference between the Fact and Application mean scores for the No Practice group (8.37 vs. 7.79). Limited Practice and Elaborate Practice were comparable in the effect on Facts (12.63 vs. 12.58), but Elaborate Practice was slightly more effective for the learning of Applications.

Insert Table 1 and Figure 1 About Here

Significant effects were also found for Test Item Familiarity, $F(1,66) = 146.58$, $p<.0001$, and for the interaction between Practice and Item Familiarity, $F(2,66) = 35.67$, $p<.0001$. As expected, repeated items were recalled at a much higher rate than new items (11.92 vs. 8.77). The No Practice group performed comparably on repeated and new items (8.12 vs. 8.04), since no opportunity for item practice was provided during the lesson. However, the comparable difficulty of repeated and new items was established. For the Limited and Elaborate Practice groups, however, repeated items were recalled at a significantly higher rate than new items, as illustrated in Figure 2. It was hypothesized that greater "spread of activation" might be expected to non-questioned lesson context --especially via the higher level application questions. This effect, however, was not detected.

The effects of orienting activities were not significant. In fact, orienting activities were found to exert almost no measurable differences in their effect on learning, with less than one raw score point difference between the No Orienting Activities and Orienting Activities groups across practice. This pattern was also evident when orienting effects were examined in conjunction with practice: virtually no measurable effects were observed.

Insert Figure 2 About Here

GENERAL DISCUSSION

The purpose of this study was to examine the effects of levels of practice and orienting activities on learning from interactive video. Consistent with previous research, practice appears to dominate the instructional effectiveness of interactive video even though the potential for widely varied presentation strategies are available. Inconsistent with the prior research, integrative questioning techniques, in the form of application questions, had little carry-over to non-practiced lesson content.

Students receiving practice, in the form of questions, outperformed groups that did not. This was expected and consistent with prior research on practice involving questions (Schloss, Sindelar, Cartwright, & Schloss, 1986). However, there were no significant differences between groups receiving limited practice and elaborate practice. This is consistent with feedback reseach performed by Kulhavy et al (1985), who reported that when increasingly complex levels of feedback are presented, the amount of learning time required increases but learner performance does not. This suggests that in many learning situations, providing the learner with simple response feedback is often as effective as elaborate practice.

The interaction between practice and type of learning revealed that both limited and elaborate practice treatments were superior to no practice, but the effect was most pronounced for facts versus applications. This is consistent with recent findings for both computer-based instruction (Hannafin, Phillips, Rieber, & Garhart, 1985) and interactive video (Hannafin, Phillips, & Tripp, 1986), suggesting that the benefits of embedded practice are greatest for the learning of simple declarative knowledge. Other types of learning, such as application learning in the present study, seem less sensitive to criterion-based questioning as a practice strategy.

Students were far more likely to respond correctly to repeated questions, those practiced during the instruction, than to new questions. This effect was expected and is consistent with the tenents of mastery-based instruction (Bloom, 1976). Some have suggested that the most reliable method for confirming learning is through the presentation of criterion questions, production of responses, provision of relevant feedback, and re-instruction of skills not demonstrated. Redundancy of exposure alone provides a plausible explanation, although such effects can be easily reconciled via a variety of learning theory paradigms. The present findings lend support for the importance of practice-test item redundancy for all criterion concepts, though the practicality of the process is questionable.

The effect of practice was limited to the specific questioned information and applications. While this was expected for factual items, which tend to limit the acquisition of non-questioned information, greater generalization was predicted for application items. Prior research has suggested that high level questions tend to increase the spread of activation by promoting the learning of both the specific questioned information and additional information presented in the lesson (Hamaker, 1986). This was thought to be especially true when the elaborate practice capabilities of interactive video, featuring review of critical visual elements associated with the task were provided(cf. Hannafin & Colamaio, 1986). However, contrary to those findings, the results of this study indicate very little spread of activation.

The absence of effects associated with orienting activities provides further evidence of the limited power of such techniques when used in combination with other instructional variables. In this study, practice, item familiarity, and type of learning collectively accounted for nearly 60% of the total score variance, while orienting activities, including both main effect and associated interactions, accounted for less than 3% of the score variance. This appears to be consistent with the results of prior research that indicated that the effectiveness of orienting activities tends to be inversely related to the degree to which other instructional variables are utilized in the lesson. Perhaps cognitive orienting tasks provide benefits not readily detectable in short-term, single topic studies by encouraging deeper levels of processing. If so, the short-term nature of the present study would minimize the chances of detecting the effect. However, compelling evidence has been reported to suggest other, more powerful instructional variables simply subsume the orienting activity effects.

Though practice in this study was defined as the presentation of criterion questions, numerous, and potentially more powerful, practice techniques have also been proposed (Salisbury, Richard, & Klein, 1985). Practice methods that promote the building of associations, the generation of meaning, and emphasis on transfer require study. In addition, though no differences were found between the two practice groups, this may have been an artifact of the content selected for the study. There is a need for research focusing on progressively elaborate forms of feedback for tasks with strong visual or aural requirements. Finally, efforts to extend the localized versus generalized effects of various embedded questioning techniques should be advanced.

The purpose of this study was to examine the effects of orienting activities and varied levels of practice on learning from interactive video. Some of the effects suggested interesting and practical implications for both future research and practice. Additional study should help to refine the methods used in the design of interactive video.

References

Anderson, J. R. (1980). Cognitive psychology and its implications. San Francisco: Freeman.

Anderson, R. C., & Biddle, W. B. (1975). On asking people questions about what they are reading. In G. Bower (Ed.), The psychology of learning and motivation Vol. 9. New York: Academic Press.

Andre, T. (1979). Does answering higher-level questions while reading facilitate productive learning? Review of Educational Research, 49, 280-318.

Ausubel, D. P. (1978). Educational psychology: A cognitive view. New York: Holt, Rinehart, & Winston.

Bloom, B. S. (1976). Human characteristics and school learning. New York: McGraw-Hill.

Brawley, R., & Peterson, B. (1983). Interactive videodisc: An innovative instructional system. American Annals of the Deaf, 128, 685-700.

Clark, R. E. (1983). Reconsidering research on learning from media. Review of Educational Research, 53, 445-459.

Clark, R. E. (1984). Research on student thought processes during computer-based instruction. Journal of Instructional Development, 7(3), 2-5.

Donahue, T., & Donahue, M. (1983). Understanding interactive video. Training and Development Journal, 37(12), 26-30.

Frase, L. T. (1971). Effect of incentive variables and type of adjunct questions upon text learning. Journal of Educational Psychology, 62, 371-375.

Gagne', R. M., Wager, W. W., & Rojas, A. (1981). Planning and authoring computer-assisted instruction lessons. Educational Technology, 21(9), 17-21.

Hamaker, C. (1986). The effects of adjunct questions on prose learning. Review of Educational Research, 56, 212-242.

Hannafin, M. J.(1985). Empirical issues in the study of computer-assisted interactive video. Educational Communication and Technology Journal, 33, 235-247.

Hannafin, M. J., Garhart, C., Rieber, L. P., & Phillips, T. L. (1985). Keeping interactive video in perspective: Tentative guidelines and cautions in the design of interactive video. In E. Miller and M. L. Mosley (Eds.), Educational media and technology yearbook. Denver, CO: Libraries Unlimited.

Hannafin, M. J., & Colamaio, M. (1986). The effects of locus of instructional control and practice on learning from interactive video. In G. Head (Ed), Twenty-eighth international conference proceedings of the Association for the Development of Computer-Based Instructional Systems

Hannafin, M. J., & Hughes, C. (1986). A framework for incorporating orienting activities in computer-based interactive video. Instructional Science, in press.

Hannafin, M. J., & Phillips, T. L. (1986). Perspectives in the design of interactive video: Beyond tape versus disc. Journal of Research and Development in Education, in press.

Hannafin, M. J., Phillips, T. L., Rieber, L. P., & Garhart, C. (1986). The effects of orienting activities and cognitive processing time on factual and inferential learning. Educational Communication and Technology Journal, in press.

Hannafin, M. J., Phillips, T. L., & Tripp, S. D. (1986). The effects of orienting, processing, and practice activities on learning from interactive video. Journal of Computer-Based Instruction, in press.

Kaplan, R., & Simmons, F. G. (1974). Effects of instructional objectives used as orienting stumuli or as summary/ review upon prose learning. Journal of Educational Psychology, 66, 614-622.

Kulhavy, R. (1977). Feedback in written instruction. Review of Educational Research, 7 (1), 211-232.

Kulhavy, R., Yekovich, F., & Dyer, J. (1976). Feedback and response confidence. Journal of Educational Psychology, 68, 522-528.

Kulhavy, R., White, M., Topp, B., Chan, A., & Adams, J. (1985). Feedback complexity and corrective efficiency. Contemporary Educational Psychology, 10, 285-291.

Mayer, R. E. (1979). Can advance organizers influence meaningful learning. Review of Educational Research, 49, 371-383.

Melton, R. F. (1978). Resolution of conflicting claims concerning the effects of behavioral objectives on student learning. Review of Educational Research, 48, 291-302.

Newell, W. J., Sims, D., & Myers, T. (1983). Principles and requisites of computer-assisted interactive video instruction: A sign language lesson. American Annals of the Deaf, 128, 662-672.

Reynolds, R., & Anderson, R. (1982). Influence of questions on the allocation of attention during reading. Journal of Educational Psychology, 74, 623-632.

Rickards, J. P. (1979). Adjunct postquestions in text: A critical review of methods and processes. Review of Educational Research, 49, 181-196.

Rickards, J. P., & DiVesta, F. J. (1974). Type and frequency of questions in processing textual materials. Journal of Educational Psychology, 66, 354-362.

Rothkopf, E. Z. (1966). Learning from written instructive materials: An exploration of the control of inspection behavior by test-like events. American Educational Research Journal, 3, 241-249.

Rothkopf, E. Z., & Bisbicos, E. E. (1967). Selective facilitative effects of interspersed questions on learning from written material. Journal of Educational Psychology, 58, 56-61.

Salisbury, D. F., Richards, B. F., & Klein, J. D. (1985). Designing practice: A review of prescriptions and recomendations from instructional design theories. Journal of Instructional development, 8 (4), 9-19.

Schaffer, L., & Hannafin, M. J. (1986). The effects of progressively enriched interaction on learning from interactive video. Educational Communication and Technology Journal, in press.

Sturges, P. T. (1978). Delay of informative feedback in computer-assisted testing. Journal of Educational Psychology, 70, 378-387.

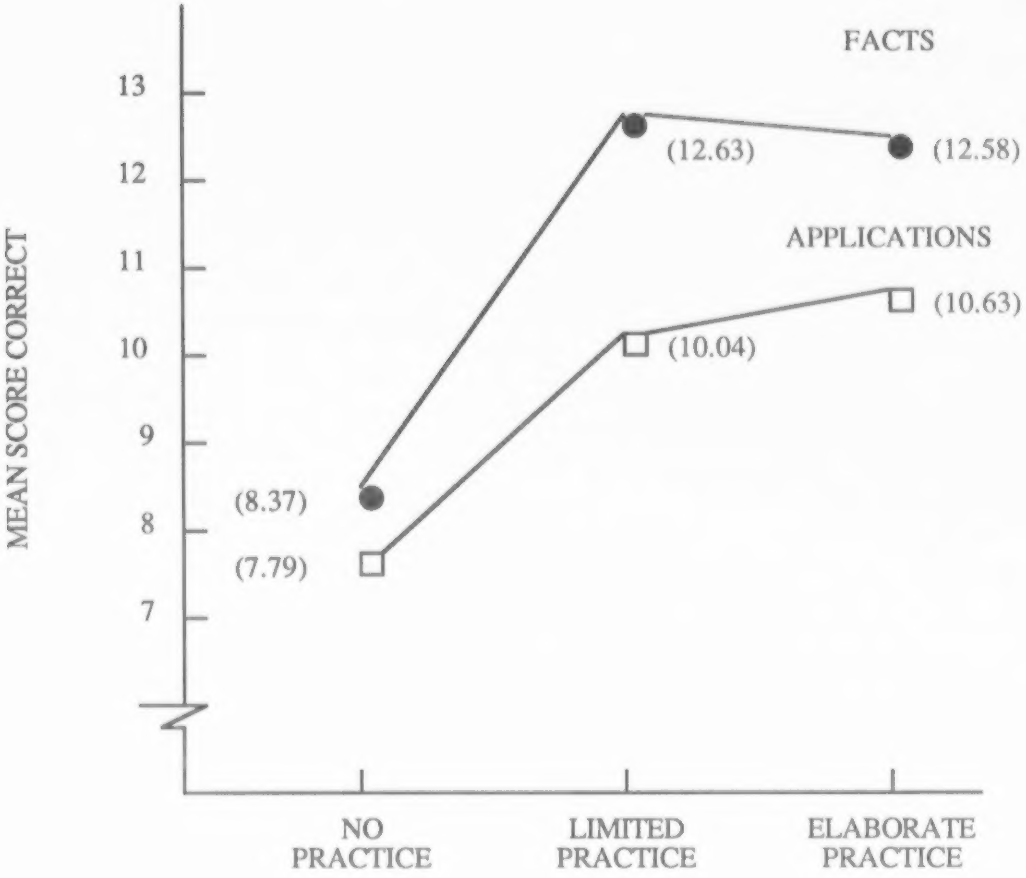
Sturm, R. (1985). High tech breakthrough: Interactive videodisc. Wilson Library Bulletin, 59, 450-452.

Wager, W., & Wager, S. (1985). Presenting questions, processing responses, and providing feedback in CAI. Journal of Instructional Development, 8 (4), 2-8.

Means and Standard Deviations for Fact and Applications Posttest Questions

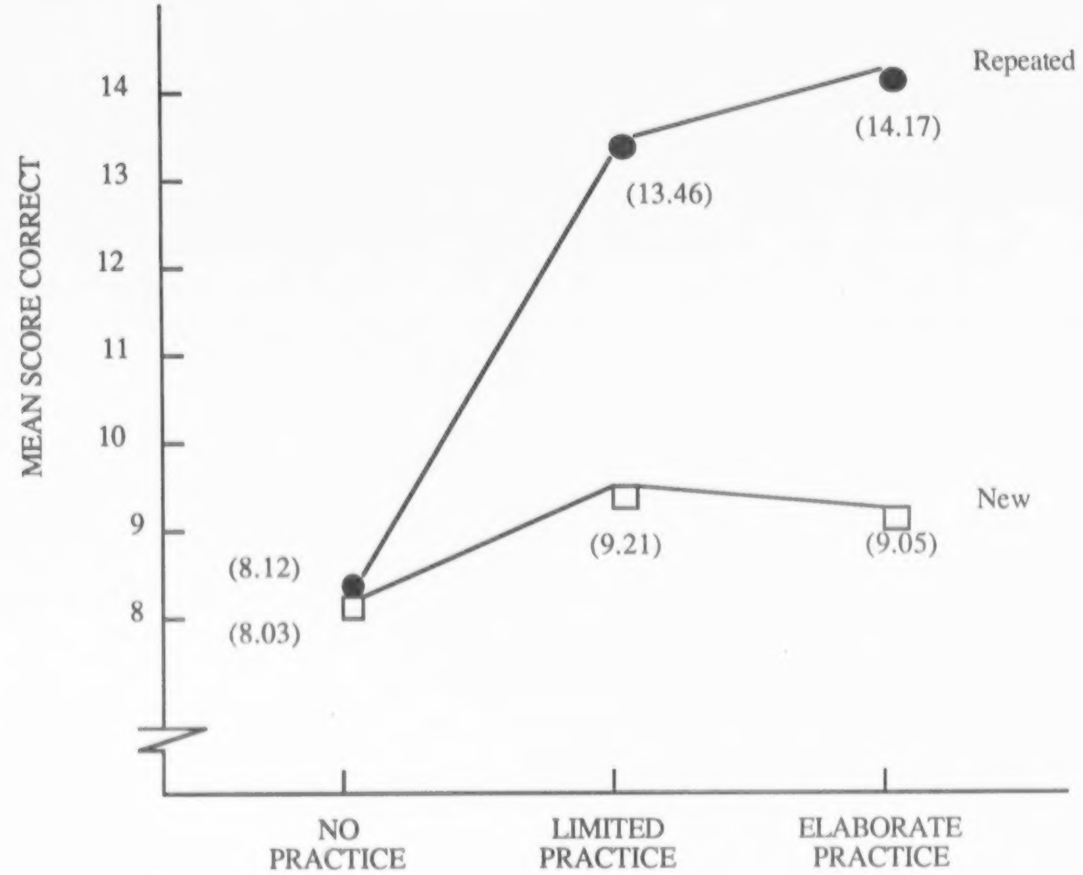
PRACTICE		REPEATED			NEW			TOTALS	
		Facts	Applications	Total	Facts	Applications	Total	Facts	Applications
None	Mean	4.04	4.08	8.12	4.33	3.71	8.04	8.37	7.79
	(SD)	1.39	1.64		1.46	1.26		2.52	2.45
Limited	Mean	7.13	6.33	13.46	5.50	3.71	9.21	12.63	10.04
	(SD)	.89	1.68		1.53	1.16		1.86	2.27
Elaborate	Mean	7.46	6.71	14.17	5.13	3.92	9.05	12.58	10.63
	(SD)	.65	1.23		1.56	1.41		1.79	2.34
	Mean	6.21	5.71	11.92	4.99	3.78	8.77	11.19	9.49
	(SD)	1.85	1.90		1.57	1.26		2.87	2.60

Note: n for each subject treatment combination = 12; total N=72



Interaction Between Level of Practice and Type of Learning

FIGURE 1



The Effects of Practice on New and Repeated Questions

FIGURE 2

The Effects of Textual and Animated Orienting Activities and Practice on Application and Problem Solving Skills in an Elementary Science Lesson: An Exploratory Study

Lloyd P. Rieber
The Pennsylvania State University
302 Rackley Building
University Park, PA 16802

Michael J. Hannafin
The Pennsylvania State University
176 Chambers Building
University Park, PA 16802

Center for Research and Development in Education Computing
Instructional Systems Program
The Pennsylvania State University

January 1, 1987

Running Head: Animated Orienting Activities

The Effects of Textual and Animated Orienting Activities and Practice on Learning from Computer-Based Instruction

Abstract

In this study, the effects of textual versus animated orienting activities and practice on the learning of elementary science material was studied. Elementary school students were randomly assigned to either a Text, Animated, Text plus Animated orienting activity group or a control group having no activity, and to either a Practice or No Practice group. Upon completion of the lesson, students were administered a posttest measuring both application and problem solving skills. Results indicated that the nature of the orienting activity did not affect the learning of either application or problem solving. However, a negative effect was found for practice.

Introduction

The science of instructional design has become increasingly interesting and complex. Recent interest in instructional design has focused on the potential of computer technology to deliver effective and efficient instruction. Much research has shown that carefully designed instruction can be delivered effectively via computer (see, for example, Edwards, Norton, Taylor, Weiss & Dusseldorp, 1975; and Bangert-Drowns, Kulik, & Kulik; 1985).

Certain features of computer technology are well-suited to the needs of instructional designers. For example, instruction can be delivered repeatedly across learners without random variation. Other features, such as the ability to branch to appropriate lesson segments based on individual learner needs and to provide appropriate and immediate feedback can be easily incorporated into computerized instruction. Lesson designers can also incorporate a wide range of teaching strategies and activities into computer-based instruction (CBI).

One goal of CBI designers is to utilize capabilities presumed to be unique to the computer. Though controversy exists as to the unique effectiveness of the computer as an instructional tool (see, Petkovich & Tennyson (1984) vs. Clark (1983); Clark, 1985), certain capabilities offer interesting instructional potential. Animation is one such capability which can be more easily integrated into computerized instruction than other instructional systems. For the purposes of this paper, animation is a series of rapidly changing computer screen displays that presents the illusion of movement (Caraballo, 1985). Computerized instruction has typically used animation as an extrinsic motivator involving such things as cartoon figures acting as feedback to student's responses. However, animation can also be used to support or enhance instruction directly and indirectly. An example of instructionally supportive animation is the animated block accelerating down an inclined plane to teach a concept in a physics class. (See Alesandrini, 1984, for a discussion of the use of visuals in instruction.)

Many perspectives on the design of effective instruction exist. Recent interest has shifted to the influence of cognitive processes during instruction (Clark, 1984; Gagne' & Dick, 1985; Hannafin & Rieber, 1986). CBI designers attempt to strengthen learning by encouraging individually relevant cognitive processes through various lesson activities or events (Gagne', Wager, & Rojas, 1981). Recent attempts to improve learning through the use of orienting activities have also been reported. An orienting activity is a mediator through which new information is presented to the learner (Hannafin & Hughes, 1986).

Orienting activities comprise advance organizers, pre-instructional objectives, pre-questions, and other similar techniques (see, for example, Allen, 1970; Alvermann, 1981; Ausubel, 1960; Kaplan & Simmons, 1974; Mayer, 1979, 1984; Walsh & Jenkins, 1973). Interestingly, the effectiveness of orienting activities during CBI has been inconsistent (Hannafin, Phillips, Rieber, & Garhart, 1986).

Recent research has demonstrated the power of practice to override effects normally expected from orienting activities (see, for example, Hannafin, 1986; Hannafin, Phillips, & Tripp, 1986). Researchers have speculated that practice often subsumes effects expected from orienting activities alone. This is consistent with the guidelines provided by Mayer (1979), who suggested that advance organizers are often unnecessary in the presence of well-designed instruction. In certain cases, practice activities may also orient learners to subsequent instruction (Phillips, Hannafin, & Tripp, 1986).

The purpose of this study was to examine the effects of different orienting activities and practice on application and problem solving skills of elementary school students. It was hypothesized that students provided orienting activities containing textual and animated information would acquire both skills more effectively than either activity alone or neither activity. It was further hypothesized that practice would be of greatest value where the orienting support was minimal.

Methods

Subjects

The subjects consisted of 111 fourth, fifth, and sixth graders from a rural public elementary school. These subjects represented approximately 80% of the student population of these grades. Participation was voluntary and selection based on parent consent. The subjects represented a typical cross-section of students typically found in an elementary school. The subjects consisted of 56 girls and 55 boys. The proportion of subjects across grade levels were 24 fourth grade, 41 fifth grade, and 46 sixth grade.

CBI Lesson Content

The CBI lesson described and explained Isaac Newton's Laws of Motion. The lesson material was divided into four parts: 1) introductory material; 2) motion resulting from equal forces in opposite directions in one dimensional space; 3) motion resulting from unequal forces in opposite directions in one dimensional space; and 4) motion resulting from equal and unequal forces in two dimensional space.

The first lesson part introduced the learner to Isaac Newton's formal discovery of certain physical laws. This part also initiated the sequence of learning activities used for the rest of the lesson. Most of the information presented in the first part was factual in nature. The second part introduced the concept that equal but opposite forces are needed to cause objects to stop. This section dealt only with one-dimensional space. The third part expanded this notion to include the effects of unequal forces acting upon a stationary object. The final direction and speed of an object is a combination of all of the forces from both directions. The third part also presented these concepts in one-dimensional space. Finally, the fourth part added the notion of two-dimensional space to the above concepts. Again, the final direction and speed of the object results systematically from the sequence of forces which acted upon it.

Each of the four lesson parts included the same two instructional segments in the same sequence: appropriate orienting activity and instructional frames. All instruction was presented at an introductory level with the technical descriptions of the forces of gravity and friction removed. Approximately 30 minutes was required to complete the lesson.

Lesson Versions

Each lesson included one of four orienting activities. Each orienting activity was controlled and paced externally and was presented immediately prior to each lesson part. Each orienting activity was presented for approximately one minute.

Text. In this orienting activity, a text-only computer screen prompted the learner to read a one sentence summary of the basic physical science concept to be discussed in the upcoming lesson part. An example of a text orienting activity is: "Read the following information carefully. It will help you in the next section. In order for a moving ball to completely stop, all forces must be EQUAL in all directions."

Animation. In this orienting activity, the learner was prompted to watch a short animation sequence. The animation sequence illustrated graphically a science concept without the use of textual information. An example of this activity is: "Watch the little ball below carefully. It will help you in the next section." A small ball was then kicked once to the right (a small arrow on the screen represented a kick) while ball movement was animated in a left to right fashion. When kicked once to the left, the ball stopped.

Insert Figure 1 About Here

Text plus Animation. This orienting activity was the combination of the above two strategies. The text and the animation orienting activity described above were shown together on the same frame while the learner was prompted to read and watch the information carefully.

No Activity. In this activity, the learner was given no information about the upcoming lesson. However, the lesson paused for roughly the same time required for the orienting activities while the following prompt was given: "The computer will be busy for about a minute. Please think about what you've read so far while you wait."

Each of the orienting activities was used in conjunction with one of the two practice variables: Practice and No Practice. The practice was provided immediately after each of the four lesson parts.

Practice. Learners were given a variety of activities to rehearse the lesson concepts. For example, one practice activity displayed a series of left and right arrows representing a sequence of kicks. The learner was then asked to choose which of four given outcomes would best describe the final motion of the ball. After responding, appropriate feedback in the form of knowledge of correct results was provided while the computer animation of the kick sequence was presented. During another practice activity, the ball was animated according to a predesigned pattern. The learner was then asked to choose which of four given kick sequences best described the motion of the ball. After responding, the learner was given appropriate knowledge of correct results. Similar practice activities were used throughout the lesson.

No Practice. In this version, students received no practice after the presentation of the lesson information. After the appropriate lesson presentation, the learner was routed directly to the orienting activity of the next lesson part.

Lesson Posttest

The 24 item posttest consisted of two types of questions: application and problem solving (Gagne', 1977). A total of 12 application questions and 12 problem solving questions were included in the posttest.

Design and Data Analysis

A 4 X 2 factorial design was used. Four levels of orienting activities (Text, Animation, Text plus Animation, None) were crossed with two levels of practice (Practice, No Practice). In addition to the independent variables, an overall achievement grade equivalent score of a standardized achievement test, was used as a covariate. This score was used in order to minimize the effects of imbalance of students from different grade levels in the various treatment combinations. MANCOVA procedures were used to analyze performance data.

Procedures

Subjects were randomly assigned to one of the lesson versions and the lesson was presented accordingly. Assignment was proportionally stratified to ensure balance of subjects from achievement levels in each lesson version. All instruction and testing was administered by computer in a lab containing microcomputers. Upon completion of the lesson, students were prompted to inform the proctor. The posttest was given to the students immediately upon completion of the lesson.

Results

Table 1 contains adjusted means for each treatment combination. No overall MANCOVA significant differences were found for orienting activities, $F(6,204)=1.13$, $p>.05$. Mean scores were comparable irrespective of the orienting activity provided. A marginally significant effect was found for practice $F(2,101)=3.67$, $p<.05$. However, the direction of this effect was not predicted. Practice actually hampered performance for both application and problem solving skills. No interactions were detected.

Insert Table 1 About Here

Discussion

The purpose of this study was to examine the effects of text-based and computer animated orienting strategies and practice on learning application and problem solving skills. The results suggest that orienting activities, whether text-based or animated, do not exert particularly powerful influences on learning.

The lack of differential effects attributable to orienting activities during computer-based instruction was consistent with several recent studies involving computer-based learning (Hannafin, 1986; Hannafin, Phillips, Rieber & Garhart, 1986; Hannafin, Phillips, & Tripp, in press). However, the activities used in the present study were believed to be consistent with the capabilities of the computer and were believed to provide powerful orienting mechanisms. The textual orientation provided a verbal representation of the science concept while the animation provided a mental image of each particular science concept.

Cognitive psychology researchers have posited mental imagery and verbal representations as primary mental structures. Many researchers have noted the power of pictures over abstract words in stimulating higher levels of retention (see for example, Bower, 1972; Paivio, 1979). This research suggests that young learners are often better able to receive information in visual versus textual ways. When information is presented in highly verbal ways, young learners often create a mental image corresponding to the presented text. The implication is when instruction contains meaningful visual images to support lesson information, such as in the text plus animation treatment, learners should be better able to both store and retrieve the information to and from long term memory.

There are several explanations which may help to clarify why an orienting activity effect was not found. First, orienting activities, such as advance organizers, are probably most useful when the subject matter lacks organization (Mayer, 1979). The instruction used in this study was carefully prepared and presented and may have subsumed potential learning gains derived from orienting activities. Due to the apparent difficulty of the lesson content, it is also possible that students never fully elaborated the material during encoding and were therefore less able to retrieve lesson information. Lastly, another possible explanation comes from Carlson, Kincaid, Lance & Hodgson (1976) who noted that students tend to revert to their own individual strategies regardless of strategy prompting during instruction. Hence, many students might simply disregard or ignore the potentially useful information or orienting strategies in favor of their own individual strategies.

The absence of the predicted interaction between orienting activity and practice was somewhat surprising. It was hypothesized that practice would decrease in power as the potential meaningfulness of material was increased. This should also be true when children are provided with elaboration or preparatory mechanisms to better encode information. It was predicted that the text plus animation activity would lessen the effect of practice since additional elaboration cues were available at the time of encoding. The absence of the interaction is probably due to the ineffectiveness of the orienting activities already discussed: orienting activities simply did not make a difference in a fully supported CBI lesson.

Practice actually exerted a negative influence on learning in this study. This result is inconsistent with other findings and should be interpreted cautiously. It is evident from an analysis of the low posttest means that the lesson material was very difficult for students to acquire. Providing additional instruction, where heavy cognitive demands were already imposed upon the learner, may have been more detrimental than helpful to learning. The additional demands of practice may have created a type of cognitive overload. This phenomena is consistent with research from other areas of instructional design such as the use of visualization. Dwyer (1978), for example, found that although the use of pictures generally facilitated learning, this was not generally true when the material to be learned was too complex. Lesson designers should be cautious in the use of additional activities when lesson material is very complex and demanding.

Several directions for further research are indicated. Although the use of animation to enhance learning appears consistent with current theories of learning, recent studies have failed support this contention (see also, for example, King, 1975; Moore, Nawrocki & Simutis, 1979; A. Caraballo, 1985; and J. Caraballo, 1985). Continued research is needed to better define where the power of animation is useful and appropriate. Although the computer can deliver instruction in a variety of modes based on a variety of conditions, such conditions must be better defined. Additional research is needed to define optimal contexts for orienting activities and practice.

This study has raised several questions concerning how students process information, as well as how computer technology can contribute to this learning process. Based on this study, it appears that orienting activities are relatively insignificant in affecting learning when part of a well designed lesson. The negative effect of practice, though perhaps a statistical anomaly, warrants closer study. Future researchers should clarify and define superior instructional design models given the evolving capabilities of technology.

References

Alesandrini, K. L. (1984). Pictures and adult learning. Instructional Science, 13, 63-77.

Allen, D.I. (1970). Some effects of advance organizers and level of question on the learning and retention of written social studies materials. Journal of Educational Psychology, 61, 333-339.

Alvermann, D.E. (1981). The compensatory effect of graphic organizers on descriptive text. Journal of Educational Research, 75, 44-48.

Ausubel, D.P. (1960). The use of advance organizers in learning and retention of meaningful material. Journal of Educational Psychology, 51, 267-272.

Bangert-Drowns, R. L., Kulik, J. A., and Kulik, C.-L. C. (1985). Effectiveness of computer-based education in secondary Schools, Journal of Computer-Based Instruction, 12(3), 59-68.

Bower, G.H. (1972). A selective review of organizational factors in memory. In E. Tulving & W. Donaldson (eds.), Organization and memory. New York: Academic Press.

Caraballo, A. (1985). An experimental study to investigate the effects of computer animation on the understanding and retention of selected levels of learning outcomes. Unpublished doctoral dissertation, The Pennsylvania State University.

Caraballo, J. N. (1985). The effect of various visual display modes in computer-based instruction and language background upon achievement of selected educational objectives. Unpublished doctoral dissertation, The Pennsylvania State University.

Carlson, R. F., Kincaid, J. P., Lance, S., & Hodgson, T. (1976). Spontaneous use of mnemonics and grade point average. Journal of Psychology, 91, 117-122.

Clark, R. E. (1983). Reconsidering research on learning from media. Review of Educational Research, 17(2), 92-101.

Clark, R. E. (1985). Confounding in educational computing research. Journal of Educational Computing Research, 1(2), 137-148.

Dwyer, F. M. (1978). Strategies for improving visual learning. State College, Pa.: Learning Services.

Edwards, J., Norton, S., Taylor, S., Weiss, M., & Dusseldorp, R. (1975). How effective is CAI? A review of the research. Educational Leadership, 33, 147-153.

Gagne, R.M. (1977). The conditions of learning (third edition). Holt, Rinehart and Winston: New York.

Gagne, R.M. & Dick (1983). Instructional psychology. Annual Review of

Psychology, 34, 261-295.

Gagne, R.M., Wager, W. W., & Rojas, A. (1981) Planning and authoring computer-assisted instruction lessons. Educational Technology, 21(9), 17-21.

Hannafin, M.J. (1986). The effects of adjunct activities versus en-route practice on the learning of cued and uncued information. Submitted for publication.

Hannafin, M.J. & Hughes, C. (1986). Utilizing orienting strategies in the design of computer-based interactive video. Instructional Science, in press.

Hannafin, M.J., Phillips, T.L., Rieber, L.P. & Garhart, C. (1986). The effects of orienting activities and cognitive processing time on factual and inferential learning. Educational Communications and Technology Journal, in press.

Hannafin, M.J., Phillips, T.L. & Tripp, S.M. (1986). The effects of orienting and processing activities and practice on learning from interactive video. Journal of Computer-Based Instruction, in press.

Hannafin, M.J., & Rieber, L.P. (1986). The role of cognitive processing during computer-based instruction. Submitted for publication.

Kaplan, R. & Simmons, F.G. (1974). Effects of instructional objectives used as orienting stimuli or as summary/review upon prose learning. Journal of Educational Psychology, 66, 614-622.

King, W. A. (1975). A comparison of three combinations of text and graphics for concept learning. (Report No. NPRDC-TR-76-16). San Diego, CA: Navy Personnel Research and Development Center. (ERIC Document Reproduction Service No. ED 112 936).

Mayer, R. E. (1979). Can advance organizers influence meaningful learning? Review of Educational Research, 49, 371-383.

Moore, M.V., Nawrocki, L., & Simutis, Z. (1979). The instructional effectiveness of three levels of graphics displays for computer-assisted instruction. (Report No. ARI-TP-359). Arlington, VA: Army Research Institute for the Behavioral and Social Sciences. (ERIC Document Service No. ED 178 057).

Paivio, A. (1979). Imagery and verbal processes. Hillsdale, NJ: Lawrence Erlbaum Associates.

Petkovich, M.D. & Tennyson, R.D. (1984). Clark's "Learning from Media": a critique. Educational Communications and Technology Journal. 32(4), 233-241.

Walsh, D.A. & Jenkins, J.J. (1973). Effects of orienting tasks on free recall in incidental learning. Journal of Verbal Learning and Verbal Behavior, 12, 481-488.

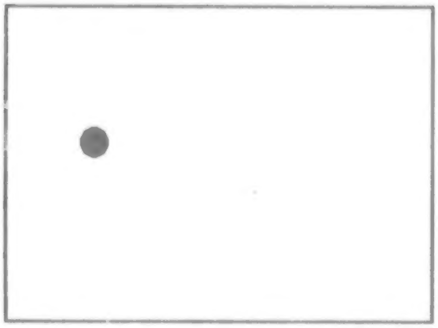
Table 1.

Adjusted Means for Application and Problem Solving Questions

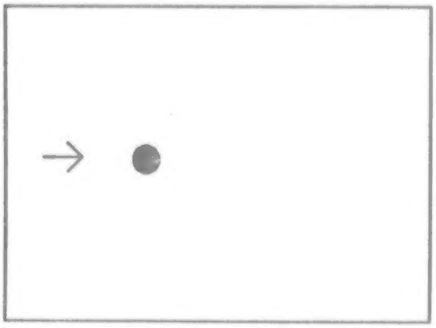
		Orienting Activity			
Embedded Activity		Text	Animated	Text + Animated	None
		Application			
Practice	Mean	4.84	5.45	4.40	4.86
	n	14	14	14	13
No Practice	Mean	6.13	4.86	5.08	4.24
	n	14	14	14	14
		Problem Solving			
Practice	Mean	5.39	4.86	4.29	5.14
	n	14	14	14	13
No Practice	Mean	5.92	5.22	6.22	6.06
	n	14	14	14	14

Figure Captions

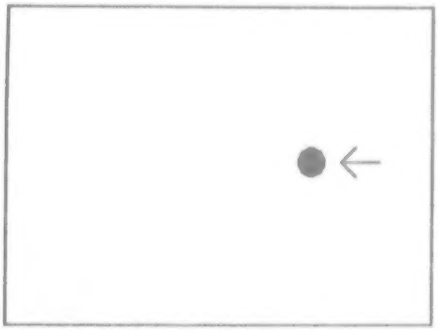
Figure 1. Time-lapse example of animation sequence.



Ball at rest.



Right kick makes the ball move to the right.



Kick from the left stops the ball.

Schema Theory and Signaling:

Implications for Text Design

Stephen Rodriguez
Center for Instructional Development & Services
Florida State University
2003 Apalachee Parkway
Tallahassee, FL 32301
(904) 487-2054

Introduction

Today, a great deal of instruction is delivered through text. However, text-based instruction does not always bring about desired results. Thus, we continue to search for ways to improve the instructional power of both paper and computer-based text displays.

A number of research areas offer direction for text design. The present discussion is limited to two areas of interest. First is schema theory which hypothesizes that comprehension hinges on whether a reader activates a schema coinciding with the author's. Second is signaling theory which hypothsizes that placing various aids within the text can promote comprehension.

This discussion considers implications of schema and signaling theory for text design; some relevant research is reviewed, and tentative conclusions and research questions are derived.

Macro Level of Text Structure

Text is commonly characterized as having two levels of structure -- the so-called 'macro' and 'micro' levels.

Various researchers have offered descriptions of the macro or 'top level' structure of text. The macro structure may refer to the schemata and patterns which authors employ to organize writing (Meyer, Brandt, and Bluth, 1980). Common patterns include narration, description, comparison, cause and effect, and so on. The macro level has also been described as "...the conceptual structure or organization of the passage" and as "...the outline structure" (Mayer, 1980, p.37). The macro level is "...global in nature, characterizing the discourse as a whole" (Kintsch & van Dijk, 1978, p.365).

An effective reader recognizes the author's schema and uses it to organize and later recall the ideas presented within the text:

> ...skilled readers appear to know the conventional organization patterns of text. They adapt a strategy of seeking and using the author's structure as an organizing framework for understanding and remembering the text structure (Armbruster, 1986, p.255).

Interaction of Micro and Macro Levels of Text Structure

The macro structure clarifies the topic of discourse and connects individual propositions comprising the microstructure (Kintsch and van Dijk, 1978). "The microstructure is the local level of the discourse, that is, the structure of the individual propositions and their relations" (Kintsch and van Dijk, 1978, p. 365).

The macro level structure of text specifies the logical connections among ideas and the subordination of some ideas to others (Meyer et al., 1980). Thus, we might conclude that a good reader does two things: one, grasps the author's organizational scheme, and two, employs that scheme while reading to clarify meaning and relationships among propositions. These actions, presumably, result in high comprehension.

Signaling

Signaling the macro level of text structure may provide the reader with a strategy for selecting, encoding, organizing, and later retrieving information (Meyer et al., 1980). Signaling involves the "...placement of non-content words in a passage, which serve to emphasize the conceptual structure or organization of the passage" (Mayer, 1984, p. 37). Signaling is "...information in text which does not add new content on a topic, but which gives emphasis to certain aspects of the semantic content or points out aspects of the structure content" (Meyer et al., 1980, p.77). Meyer (1975) discusses four types of signaling as follows:

> 1) "pointer words...explicitly inform the reader of the author's perspective of a particular idea" (p.80), e.g.-- UNFORTUNATELY, true needs assessments are rarely conducted;
>
> 2) prematurely revealed information refers to presenting a preview of content presented later in the text, e.g. -- This chapter includes discussion of simile, metaphor, personification, and alliteration;
>
> 3) summary statements restate major points presented in the passage, e.g. --

> In summary, formative evaluation
> includes one-to-one, small-group, and
> field
> test phases;
>
> 4) "specification of the structure of relations" (p.77) refers to wording which functions as a cue to the reader regarding the relationships of ideas within a given content structure, e.g. -- THE PROBLEM is that the shoreline erodes: THE SOLUTION is to apply soil conservation techniques.

Research on the Effects of Signaling

Some research has explored the effects of using explicit statements and underlined pointer words to signal text. Explicit signals of the structure of relationships among propositions increased the amount of information recalled on an immediate recall test (Meyer et al., 1980). The signals were conceived to have increased the saliency of the macrostructure. Unfortunately, signaling did not appear to affect recall on a retention test. (A sample of the signaled text employed in this study is presented in Appendix A.)

In a related study, text was signaled using preview sentences to state the purpose of the text and to provide an overview of the content (Loman and Mayer, 1983). Underlined headings were used to dilineate the organization of the content. Logical connectives (key words) were inserted to emphasize the cause and effect relationships among propositions. The researchers hypothesized that such signaling would encourage use of a "meaningful reading strategy" (as oppposed to rote reading strategy) and promote recall of conceptual information and subsequent problem solving. Signaling appeared to promote subjects' ability to solve problems and to recall conceptual information but not to recall verbatim information. The researchers thus see signaling as a tool for emphasizing the conceptual structure and causal links in text. By understanding the organization of the text, the reader may be better able to connect propositions and make inferences.

There would appear to be value in continued research on signaling. Loman and Mayer (1983) suggest that researchers employ dependent measures which will reveal what -- not how much -- is learned. They urge further investigation of the characteristics of useful signals and of the effects of signals in large bodies of text.

Form Schema and Schema Induction

Brooks and Dansereau (1983) describe a form or structural schema which is said to contain information on the format of text. These authors suggest that use of a form schema can facilitate processing of "academic material." The form schema specifies categories of information that the learner is expected learn.

The researchers surveyed a variety of learners and derived a form schema for scientific theories. Some learners subsequently received training in use of a form schema as a learning aid. Those subjects completing a six hour training session on the use of the scientific theory form schema recalled more main ideas than other subjects. Also, text organized according to the form schema was shown to produce greater recall than alternatively organized text.

Organizing material consistently and emphasizing the formal components of text structure may thus help the reader to formulate and develop a new schema coinciding with the organization of the text. Such schema induction has been described by Rumelhart (1980) as the classical contiguity of learning. He proposes that "...if a certain spatio-temporal configuration of schemata is repeated, there is reason to assume that the particular configuration forms a meaningful concept and a schema can be formed that consists of just that configuration" (p. 54). Thus consistency of organization is seen as an important element in efficient text design. The idea of repeating a "spatio-temporal configuration" to form a new schema merits further investigation.

Guidelines for Computer and Paper-Based Text Displays

The question of how to design efficient computer-based text displays still remains.

Programmers and CAI developers have long known that the space within the computer display provides an essential basis for text organization. Various locations within the display are used consistently to clarify the nature of various types of information. For instance, a title, main heading, or rule statement may appear at the top of the page. An example, illustration, or list of associated facts may appear in the middle area. Prompts are usually placed at the bottom of the screen. Similarly, when presenting questions, the core question is presented, followed by the response choices. Feedback often appears beneath the question in a consistent location. The so-called 'paging' approach to CAI programming allows for control of the spatial organization of a given display and is thus superior to the 'scrolling' technique.

Both computer and print displays can be designed and structured to emphasize schema slots. Schema slots can be emphasized and differentiated spatially within a display to promote the reader's selective perception. Further, mapping may be incorporated whereby certain spatial positions and certain standard symbols stand for relationships among the ideas within the text (Armbruster and Anderson; 1980; Gagne, 1986).

Various other text manipulations can also serve to emphasize the distinctive features of a given display and to "draw the learner's attention" to important information. Possibilties include underlining, using italics, listing, bolding, or otherwise highlighting features of the material to be selectively perceived (Gagne, 1985).

Signals in Computer Displays

No one has yet investigated how signaling techniques may be integrated in computer displays. It is unknown whether signals in computer-based lessons might have the same sorts of effects as signals in paper-based text.

In an attempt to explore possible uses of signals in computer displays, this author developed a short computer lesson on the workings of an electric bell. The lesson begins with an brief explanation of the organization of the information within the lesson (i.e., the purposes of the signals employed are explained). The lesson then presents one proposition at a time. The elements within each proposition are signaled to indicate the relationships among the presented words. The subject of each proposition is labeled as PART; the requisite action necessary for the identified PART to function is labeled ACTION; and the consequence of the PART functioning is labeled RESULT. Each component was further differentiated in space. (See Appendix B for samples of the signaled computer-text displays.)

It was conceived that the signals would emphasize the key components of the propositions, clarify the relationships among components of each proposition, and promote recollection of the explained information. Results of a pilot test show a trend in this direction.

The idea of signaling elements of propositions may merit further consideration. Such an approach might be useful in language and grammar instruction or when the instructional content can be structured consistently and is suitable for a "proposition by proposition" presentation.

Conclusion

Much work is yet to be done if we are to clarify possible relationships among schemata, comprehension, text organization, and text enhancements such as signaling. Given the overwhelming amount of text-based instruction and our progress to this point, issues of text design surely merit further exploration.

References

Armbruster, B. B. (1986). Schema theory and the design of content-area textbooks. Educational Psychologist, 21(4), 253-267.

Armbruster, B. B., & Anderson, T. H. (1980). Effects of mapping on the free recall of expository text. Urbana, IL: Center for the Study of Reading (Tech. Rep. No. 160).

Brooks, L. W., & Dansereau, D. F. (1983). Effects of structural schema training and text organization on expository prose processing. Journal of Educational Psychology, 78(6), 811-820.

Gagné, R. M. (1985). The conditions of learning (4th ed.). New York: Holt, Rinehart and Winston.

Gagné, R. M. (1986). Instructional technology: The research field. Journal of Instructional Development, 8(3), 7-14.

Kintsch, W., & van Dijk, T. A. (1978). Toward a model of text comprehension and production. Psychological Review, 85(7), 363-393.

Loman, N. L., & Mayer, R. E. (1983). Signaling techniques that increase the understandability of expository prose. Journal of Educational Psychology, 75(3), 402-412.

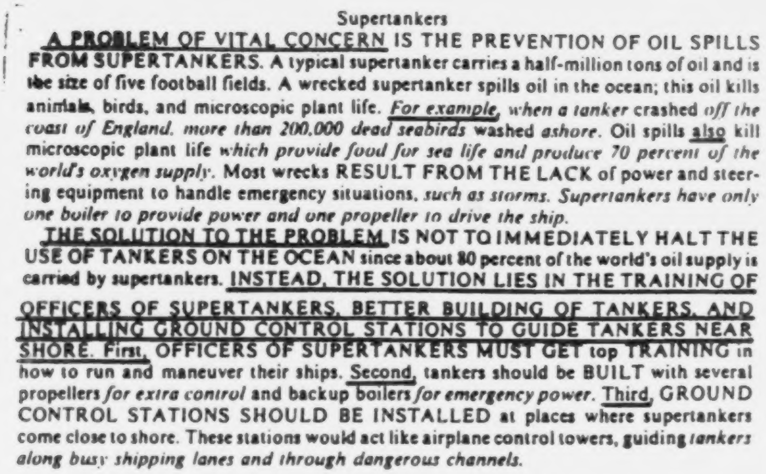
Mayer, R. E. (1984). Aids to text comprehension. Educational Psychologist, 19(1), 30-42.

Meyer, B. J. F. (1975). The organization of prose and its effects on memory. New York: American Elsevier.

Meyer, B. J. F., Brandt, D. M., & Bluth, G. J. (1980). Use of top-level structure in text: Key for reading comprehension of ninth graders. Reading Research Quarterly, 16(1), 72-103.

Rumelhart, D. E. (1980). Schemata: the building blocks of cognition. In R. J. Spiro, B. C. Bruce, & G. W. F. Brewer (Eds.), Theoretical issues in reading comprehension (pp. 33-58). Hillsdale, NJ: Erlbaum Associates.

Appendix A



Supertankers

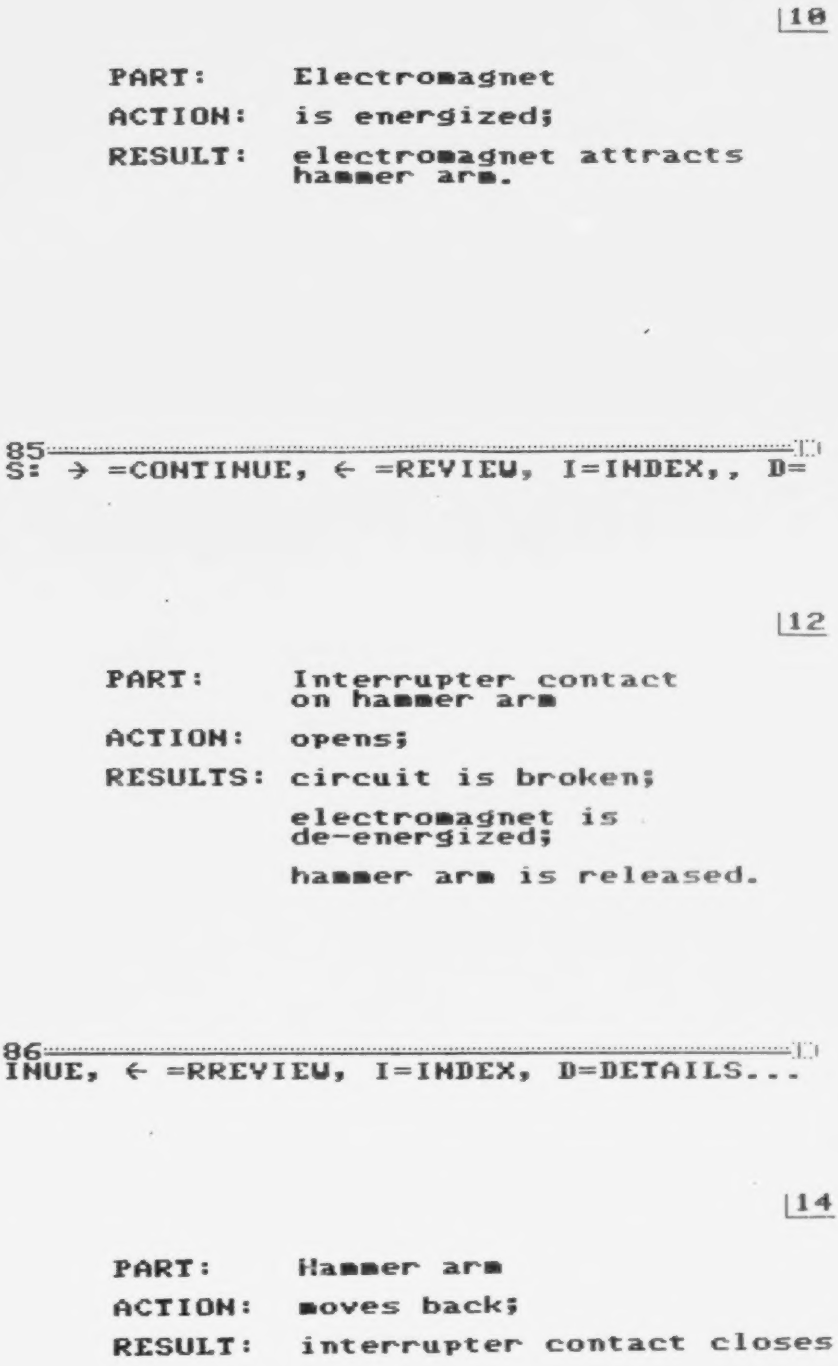
A PROBLEM OF VITAL CONCERN IS THE PREVENTION OF OIL SPILLS FROM SUPERTANKERS. A typical supertanker carries a half-million tons of oil and is the size of five football fields. A wrecked supertanker spills oil in the ocean; this oil kills animals, birds, and microscopic plant life. For example, *when a tanker* crashed *off the coast of England, more than 200,000 dead seabirds* washed *ashore*. Oil spills also kill microscopic plant life *which provide food for sea life and produce 70 percent of the world's oxygen supply*. Most wrecks RESULT FROM THE LACK of power and steering equipment to handle emergency situations, *such as storms. Supertankers have only one boiler to provide power and one propeller to drive the ship.*

THE SOLUTION TO THE PROBLEM IS NOT TO IMMEDIATELY HALT THE USE OF TANKERS ON THE OCEAN since about 80 percent of the world's oil supply is carried by supertankers. INSTEAD, THE SOLUTION LIES IN THE TRAINING OF OFFICERS OF SUPERTANKERS, BETTER BUILDING OF TANKERS, AND INSTALLING GROUND CONTROL STATIONS TO GUIDE TANKERS NEAR SHORE. First, OFFICERS OF SUPERTANKERS MUST GET top TRAINING in how to run and maneuver their ships. Second, tankers should be BUILT with several propellers *for extra control* and backup boilers *for emergency power*. Third, GROUND CONTROL STATIONS SHOULD BE INSTALLED at places where supertankers come close to shore. These stations would act like airplane control towers, guiding *tankers along busy shipping lanes and through dangerous channels.*

Signaled text used in study by Meyer et al., 1980

BEST COPY AVAILABLE

Appendix B



```
                                                          10

PART:      Electromagnet

ACTION:    is energized;

RESULT:    electromagnet attracts
           hammer arm.


85
S: → =CONTINUE, ← =REVIEW, I=INDEX,, D=


                                                          12

PART:      Interrupter contact
           on hammer arm

ACTION:    opens;

RESULTS:   circuit is broken;

           electromagnet is
           de-energized;

           hammer arm is released.


86
INUE, ← =RREVIEW, I=INDEX, D=DETAILS...


                                                          14

PART:      Hammer arm

ACTION:    moves back;

RESULT:    interrupter contact closes
```

Signaled computer displays on the workings of an electric bell.

Effects of Media on
Children's Inference Justifications

Stephen R. Rodriguez,
Deborah S. King, &
Naja G. Williamson
Florida State University
College of Education
307 Stone
Tallahassee, FL 32306-3030

Abstract

This study examined whether the sources of information children use to substantiate story-based inferences are influenced by the medium of delivery. Forty-eight third graders were stratified by sex and randomly assigned to one of two media conditions. Each child was presented an African folktale either as a televised story or as a storybook narrated by an audio cassette tape. Following presentation of the story, students were asked a series of inference questions and asked to justify their answers. Each inference justification was classified as either visual, audio, audio-visual, or outside-of-story based. Children who saw the televised story used visual and audio-visual information to justify their inferences more often than did the children who heard and saw the narrated, storybook version. Conversely, children in the storybook condition based significantly more inferences on audio information than did subjects viewing the televised story. These results indicate that when selecting media for use in presenting information to children, consideration should be given to the specific attributes of the media to which children attend.

Background

Children in our society are exposed to stories through a variety of media such as picture books, radio, audio cassette, film, and television. Numerous studies have been conducted to investigate the learning that occurs when children are presented stories via various media (Wetstone & Friedlander, 1974; Roberts & Bachen, 1981; Williams, 1981). The methodology and analyses employed in these and other studies allow only the investigation of overall effects produced by the different treatments -- i.e., with what medium does the most learning occur? Little attention is paid to the specific attributes of the media which might account for any differences.

Schramm (1979) has been critical of the approaches that characterize the so-called "intermedia" studies. He notes the lack of "studies intended to ascertain under what conditions and for what purposes one medium may be superior to another" (p.33). Recently, researchers have investigated the characteristics of different media which enhance specific types of learning in given contexts. Meringoff (1980), for instance, found that children's recall of story actions was enhanced by a televised presentation of the story. Conversely, recall of story vocabulary was greater for children who had read a storybook version. These findings offer evidence that the differences in media presentations influence what content is learned. Television's animation may emphasize the visual content, while the still pictures in a storybook may allow greater attention to be paid to the narration.

In a related study Beagles-Roos & Gat (1983) examined the specific strengths of a televised presentation and a radio presentation of a story. Equivalent recall of story content was reported for both media. There were differences, however, in the types of information recalled. Children viewing the televised version recalled more details, while children in the radio condition recalled more expressive language. As in the Meringoff research, these differences are thought to be a result of specific attributes of the media. The pictures and animation provided visual enhancement leading to greater recall of details. Visuals were absent in the radio presentation, thus allowing more attention to be paid to the narration. This medium, therefore, resulted in greater recall of expressive language.

The Meringoff and Beagles-Roos and Gat studies indicate that children attend to different stimuli present in various media. For example, it seems plausible that children would focus on the video rather than the audio features of television. In support of this view, Ward and Wackman (1973) present a model of information processing for televised events; this model accounts for the age of the viewer. The model suggests that preschool children do attend primarily to visual presentations, often completely ignoring audio portions. As children mature, they begin taking into account both sources of information.

There appears to be support for the Ward and Wackman model in a number of settings involving children. For example, grade children have been shown to exhibit more accurate retention of the visual content rather than verbal content of movies (Hale, Miller, & Stevenson, 1968). More recently, researchers also found that children recalled more visual portions than auditory portions from television commercials (Zuckerman, Zeigler, and Stevenson, 1978). Children were also found to attend more frequently to visual elements in televised cartoons (Hayes & Birnbaum, 1980). Each of these findings, however, is limited to the set of learner characteristics and type and length of events portrayed in the particualr study. Therefore, before it can be stated definitively that children attend differentially to visual and auditory segments of televised events, additional research is required with other age groups and different events.

The present study was designed to investigate whether stories presented in two different media affect the type of information used to justify story-based inferences. Some subjects saw the story on television while others saw the storybook version with accompanying audio-tape narration. Subjects were asked questions about the story for which they had to infer answers. Subjects were also asked to subtantiate their inferences. Inference justifications were categorized as being based on visual, audio, audio-visual, or outside of story information.

It was anticipated that subjects would respond differently to the inference justification questions based on the medium of presentation. Children who viewed the televised version were expected to focus their attention on story content primarily portrayed visually. Specifically, these children were expected to depend heavily on the animated actions of characters for justifying their story-related inferences. Children who heard the storybook version were expected to attend more to the verbally depicted events, and thus base more of their inference justifications on narrative passages and descriptions rather than on illustrations or animation. These finding would be in keeping with results of similiar studies (Meringoff, 1980; Beagles-Roos & Gat, 1983).

Method

Subjects

Subjects in this study were 46 third-grade children enrolled in the Developmental Research School, a laboratory operated by Florida State University in Tallahassee. The students in this school are selected to be representative of the school-age population of the State of Florida with respect to academic ability, sex, race, and socio-economic level. Twenty-two girls and 24 boys participated.

Materials

The materials selected for use in this study consisted of two versions of an African folktale, entitled A Story, A Story. One version of the story was a traditional 32-page picture book, illustrated with woodcuts. A second video version was an animated cartoon adopting the same graphic style as the storybook. Both versions used the same soundtrack narrated by a male speaking with an African accent. Thus, soft, African background music and the native accent of the narrator were consistent across both versions. The content of the soundtrack was nearly identical to the textual content of the storybook. Delivery of each version lasted approximately eight-and-one-half minutes.

A posttest consisting of five questions was designed to assess the children's ability to draw and substantiate inferences about characters' actions, feelings, and intentions. The oral posttest was administered to each child by an administrator immediately following the presentation.

Procedure

The children who participated in the study were stratified by sex and then randomly assigned to one of the two treatment groups and to a member of the research team. Members of one group were individually presented the videotaped version of the folktale and members of the other group saw and heard the storybook version. Because of scheduling constraints, a disproportionate number of subjects viewed the video presentation (n = 26) as opposed to experiencing the storybook condition (n = 20).

The story treatment was presented individually to each child a single time. The administrator listened to and/or watched the story along with each student. In the book condition, the administrator sat close to the child to enable the student to see each page while the narration was being delivered. The administrator turned the book's pages so that the text and illustrations were synchronized with the content of the soundtrack. In the video presentation, the child also sat close to the experimenter to watch the television monitor that stood equidistant in front of them at the child's eye level.

Immediately following the presentation, the administrator posed the five story-based inference questions and recorded the conversation on audio cassette. Prior to asking the first question, the administrator encouraged the child to answer all of the questions. If the student did not respond to the question within a reasonable length of time, the administrator provided a nonspecific prompt (e.g., "Can you remember anything about that?") to elicit a response. If the subject still could not respond, the administrator asked the next question. Upon completion of the questioning, subjects were told not to discuss the story with their peers.

Measures

The responses of the children to the five inference questions were recorded, subsequently analyzed, and then classified into four categories established by the experimenters prior to the implementation of the treatment. These categories were as follows: 1) visual, 2) audio-visual, 3) audio, and 4) outside-of-story. Visual information was defined as information depicted solely in the visual portion of the presentation (e.g., the woodcut illustrations and animated woodcut illustrations). Audio-visual information referred to information portrayed in both the visuals and the narration, but not necessarily concurrently. Audio information was defined as information presented only in the story soundtrack. Finally, outside-of-story information was based upon general information not presented in the story.

The three experimenters collaborated in scoring the students' responses according to predetermined criteria.

The following examples serve to further clarify the categorizations of the justification statements made by the children. Responses coded as relying on visual content consisted primarily of action descriptions (e.g., the way the fairy was struggling). For justifications based upon auditory information, the child recalled the story dialogue (e.g., "she [the fairy] was furious." This information is stated by the narrator). Responses coded as relying on audio-visual content include "It took a long time for Ananse to tie up the leopard because he had to tie up all of his feet." (The illustration depicts all of the leopard's feet bound together and the narration states Ananse tied the leopard "by the foot, by the foot, by the foot, by the foot.") In responses determined as outside-story sources, children drew upon their general knowledge (e.g., "leopards are heavy").

Results

The dependent variable -- i.e., the type of information children used to justify their inferences -- was measured by the number of justifications categorized as either audio, visual, audiovisual, or outside-of-story. Means and standard deviations associated for these categories were calculated for both the storybook and video treatments and are presented in Table 1.

The forty-six scores, categorized by basis of justification, were first examined visually. No extreme or aberrant scores were noted; the scores appeared to be consistent with the normality assumption. Hartley's Fmax test revealed that the variability of scores was similar for both conditions, thus, supporting the assumption of homogeneity of variance, Fmax (2,20) = 2.25, p > .05.

Insert Table 1 about here.

Results were tested for statistical significance using two-tailed t-tests. An alpha level of .05 was set. A comparison of the mean scores in each category across the two treatment conditions revealed a significant difference between the means in three of the four categories.

The major hypotheses regarding the nature of subjects' inference justifications were supported. As anticipated, the number of story-based inferences relying on visual information were substantially greater for those children experiencing the video condition, t(44) = 3.41, p < .001. Video subjects also employed more audio-visual information to substantiate inferences than did storybook children, t(44) = 2.18, p < .05. Conversely, the number of inferences based on auditory information were significantly greater for the storybook condition, t(44) = -2.45, p < .05. In addition, children in the video condition utilized visual plus audio-visual information to a greater degree as a basis for their inferences, t(44) = 4.13, p < .0001.

An examination of the number of subjects who failed to respond to initial inference questions prompted additional analysis. Post hoc analysis revealed that storybook subjects generated fewer initial inferences than did video subjects. This trend, however, did not reach significance, $\underline{t}(44) = 1.71$, $\underline{p} < .10$.

Discussion

The present study confirms previous research findings regarding the differential effects of video and storybook presentations on children's inference justifications (Meringoff, 1980; Beagles-Roos & Gat, 1983). Specifically, results provide added evidence that television conveys visual information more effectively than a storybook presentation. Further, a storybook presentation appears to promote greater attention to audio information such as story narration and dialogue. Apparently, since a video presentation inherently offers more salient and dynamic visual imagery than does a storybook presentation, the video medium promotes subjects' attention to visual information while simultaneously facilitating the encoding and learning of that information. On the other hand, in the storybook medium, visual information is inherently less salient than audio information. Thus, a storybook presentation promotes attention to audio information and facilitates the learning of that information.

An incidental finding of the present study was that video subjects based a significantly greater number of inferences on audio-visual information than did storybook subjects. This result suggests that audio-visual information is more effectively conveyed via video than via a storybook presentation. Also, subjects experiencing the video presentation may have attended to the story presentation more closely than storybook subjects. Since information categorized as audio-visual was presented in both narrative presentations, storybook subjects could have potentially based as many inferences on audio-visual information as did video subjects. Possibly, visual information is simply more easily encoded and learned by children than is audio, textual information. Since video subjects were exposed to more visual information than storybook subjects, and since visual information may be more readily learned by children than textual information, video subjects may have stored more audio-visual information than storybook subjects. It is difficult to draw more definitive conclusions regarding subjects' use of audio-visual information since, as Beagles-Roos &

Gat (1983) suggest, such information is presented both verbally and visually and there is no way to assess which channel a given subject employed.

Analysis of results also revealed a trend for video subjects to make a greater number of initial inferences than storybook subjects . This result is consistent with previous research findings which suggest that children apply more sophisticated inference strategies after viewing a video presentation than after experiencing non-video presentations (Schultz & Butkowsky, 1977; Beagles-Roos & Gat, 1983). The video medium and its dynamic representation of visual information may promote children's interest in narrative content and thus increase the extent to which children "think about" narrative elements. Another plausible explanation is that children possess stronger television viewing skills than the listening skills required to encode and store the information presented via a storybook presentation. Because of well developed television viewing skills, video subjects may have simply stored more story-related information, thus facilitating inference making.

One limitation on the generalizability of this study's findings has to do with the materials which were employed. Both the studies of Meringoff (1980) and Beagles-Roos & Gat (1983) utilized "A Story, A Story," which was also employed in the present study. Future researchers investigating the differential effects of media atributes on children's inference justifications should use narrative material other than "A Story, A Story." By utilizing different narrative material, researchers may be able to further verify and increase the generalizability of extant findings.

Evidence suggests that video effectively conveys visual information to children. Other studies might compare how video presentations and text with audio presentations differentially affect learning of expository, non-narrative material. For instance, many mathematical concepts may be depicted visually. Might learning materials in the video format produce greater learning of mathematical concepts than materials incorporating text and audio components? Also, is the storybook format a more effective medium for teaching language skills than the video format? How else might the salient visual imagery associated with video presentations be effectively utilized to facilitate learning? What results would occur if secondary or college level students were used as experimental subjects to compare the effects of video and storybook narrative presentations?

Indeed, while many questions remain regarding the effects of various media attributes on learning, it seems clear that video-based narrative presentations effectively convey visual information while storybook presentations promote attention to textual, auditory information. Such specification of the effects of media attributes will hopefully contribute to the articulation of further research questions regarding the effects of various media attributes on learning.

Table 1

Mean Responses of Students by Source of Information for Justification of Inferences

Source of Inferences		Treatment Television (n=26)	 Storybook (n=20)	t
Visual Information	Mean	1.27	.55	3.41*
	SD	.78	.61	
Auditory Information	Mean	.96	1.60	2.45**
	SD	.87	.88	
Audio-visual Information	Mean	1.46	.95	2.18**
	SD	.91	.61	
Outside-of-Story Information	Mean	.92	1.05	.49
	SD	1.02	.61	

* p < .001 (two-tailed test)

** p < .05 (two-tailed test)

References

Beagles-Roos, J., & Gat, I. (1983). Specific impact of radio and television on children's story comprehension. Journal of Educational Psychology, 75, 128-137.

Hale, G. A., Miller, L. K., & Stevenson, H. W. (1968). Incidental learning of film content. Child Development, 39, 69-77.

Hayes, D. S. & Birnbaum, D. W. (1980). Preschoolers' retention of televised events. Developmental Psychology, 16, 410-416.

Meringoff, L.K. (1980). Influence of the medium on children's story apprehension. Journal of Educational Psychology, 72, 240-249.

Roberts, D. F., & Bachen, C. (1981). Mass communication effects. Annual Review of Psychology, 305-356.

Schram, W. (1977). Big media, little media. Beverly Hills: Sage.

Schultz, T., & Butkowsky, I. (1977) Young children's use of the scheme for multiple sufficient causes in the attribution of real and hypothesized behavior. Child Development, 48, 464-469.

Ward, S. & Wackman, B. D. (1973). Children's information processing of television advertising. In P. Clark (ed.), New models for mass communication research, Beverly Hills: Sage.

Wetstone , H. & Friedlander, B. (1980). The effect of live, TV and audio story narration on primary grade children's listening comprehension. Journal of Educational Research, 68, 32-35.

Williams, B. T. (1981). How and what do children learn from television? Human Communication Research, 7, 180-182.

Zuckerman, M., Zeigler, M., & Stevenson, H. (1978). Children's viewing of television and recognition of commercials. Child Development, 49, 96-106.

Computer-Based Instruction Research: Implications for Design

Steven M. Ross
Foundations of Education
Education 401
Memphis State University
Memphis, TN 38152

Gary R. Morrison
Department of Curriculum and Instruction
Education 424
Memphis State University
Memphis, TN 38152

Pandma Anand, and Jacqueline K. O'Dell

Running Head: CBI Research: Implications for Design

Abstract

Solving verbal problems is one of the more difficult challenges in mathematics learning at all educational levels. The present paper describes the development and evaluation of several microcomputer-based strategies designed to personalize examples in accord with individuals' backgrounds and interests. In one study a personalized lesson on division of fractions was presented to elementary school children by computer-based instruction (CBI); in a second study computer-generated print versions of the personalized materials were administered. Comparisons with nonadaptive (standard) instructional materials were consistent across studies by showing strong advantages for the personalized examples on both achievement and attitude measures. Follow-up research is being performed to extend the strategy to older students by allowing them to select preferred themes for example problems in a CBI statistics lesson.

Computer-Based Instruction Research:
Implications for Design

In a recent article David Berliner (1986) reminds us of some ideas about teaching and learning proposed by the early 19th century philosopher/psychologist J. F. Herbart. Specifically, Herbart theorized that people learn new information only as it relates to what is already in their minds. Systematically relating instructional material to existing knowledge can therefore support the dual purposes of facilitating meaningful learning and increasing interest in the task. Over 100 years later these same ideas are expressed in the contemporary writings of noted cognitive theorists such as Ausubel (1968), Glaser (1984), and Mayer (1975). The research described in this paper was designed to apply these notions to mathematics learning, specifically, the solving of verbally stated problems.

Context Model

The instructional theory underlying the present research interests is philosophically grounded in current cognitive interpretations of learning (Anderson, 1984; Ausubel, 1968; Mayer, 1975; Rumelhart & Ortony, 1977). These conceptions interpret memory as consisting of systematically arranged networks of connected facts and ideas, called schemata. When new information is easily integrated into existing schemata, meaningful learning is engendered. The challenge for instructional design is to develop ways of facilitating the development of these cognitive structures in students through applications of technology, given that each individual enters the learning situation with different experiences, interests, motivations, and subject-matter knowledge. CAI is well-equipped to address such individualized needs, but that potential is largely unused in conventional applications.

Our specific theoretical orientation focuses on the role of the contextual properties of mathematics instruction in relation to learner characteristics and cognitive abilities. The literature on problem-solving suggests that novices (e.g., young math students) tend to be more attentive to instructional contexts than are experts who tend to focus more on intuitions and general heuristics that transfer across many different problem-solving domains (Chi, Feltovich, & Glaser, 1981; Chi, Glaser, & Rees, 1982; Dreyfus & Dreyfus, 1986). The novice may therefore, view all problems dealing with a certain physical property, such as velocity, as the same even though their structures may be quite different.

Within this framework and drawing upon several of our own preliminary investigations in laboratory and school settings, our interest concerns the influences on mathematics learning of three types of contextual factors.

We have represented them pictorially in Figure 1. The first factor, which we call extrinsic contextual properties, concerns the nominal features of the lesson, i.e., the actual set of materials presented to the learner. Attributes of this category would typically include the type and quantity of information provided (text, problems, figures, etc.), task difficulty and readability, the teaching approach used (tutorial, drill, etc.), delivery medium, and the adjunct aids (examples, questions, and prompts) incorporated. Separate from these external attributes are what we call intrinsic contextual properties that determine the relatability of the material to students' knowledge schema and interests. Accordingly, two math lessons may be identical in structure, difficulty, and teaching orientation, but differ substantially in meaningfulness as a function of the types of themes and applications they convey (Ross, McCormick, & Krisak, 1986). The nominal lesson may therefore be very different from the functional lesson with regard to what they learner attends to, processes, and recalls (Shuell, 1986). A third factor, which we call social contextual properties, concerns the influences on learning of interacting with other students in classroom setting. A given lesson may thus have very different implications for performance, attitudes, and socialization when administered in individualized as opposed to group-learning situations (Johnson & Johnson, 1986). The three types of contextual properties are assumed to operate interactively, as represented in Figure 1. For example, the quantity of instructional support (extrinsic context) considered optimal for a student might significantly vary depending upon the familiarity of the applications conveyed (intrinsic context) and whether the student is learning alone or in a group.

Insert Figure 1 About Here

In our future research, computer-based instructional strategies relating to each type of contextual influence will be examined independently and in combination. The strategies specifically concern the variables of text density (extrinsic), meaningfulness of problem themes (intrinsic), and learning group size and composition (social). Major assumptions are that the strategies will enhance learning and improve attitudes toward mathematics instruction; and comprise practical and logical extensions of the learning adaptations featured in conventional CAI methods and software. In the remainder of this paper we will describe our recent investigations of the intrinsic component of the contextual model, namely microcomputer-based strategies for personalizing math materials for elementary school students.

Personalizing Strategies

The difficulty that many students experience on verbal problems (National Assessment of Education Progress, 1979) appears to stem less from a lack of computational skills than from the inability to comprehend what the problems are asking (De Corte, Verschaffel, & De Win, 1985; Knifong & Burton, 1985; Muth, 1984; Riley, Greeno, & Heller, 1983; Zweng, 1979). Several factors, such as poor reading skills (Marshall, 1984) and lack of familiarity with problem structures (Mayer, 1982; Rosen, 1984), contribute to these difficulties. Of present concern are the contextual or "thematic" properties of verbal problems in relation to students' backgrounds and interests. To return to the assumptions by Herbart noted in the introductory paragraph, it seems likely that a math problem describing some abstract or highly technical application would have more limited potential to facilitate information processing and meaningful learning than one describing something familiar and interesting to the individual (e.g., using percentages to calculate one's intramural batting average or free-throw accuracy). Effective mathematics teachers routinely search for ways of capitalizing on students' natural interests, such as integrating lessons with class field trips (Wright & Stevens, 1983), with students' academic backgrounds (Ross, 1983), or with interesting applications in books (Jones, 1983) and newspapers (Daruwalla, 1979). Although these approaches are certainly commendable, a common weakness is their orientation to the activities of a group rather than to the idiosyncratic experiences of individuals. Individualizing materials overcomes this limitation but is obviously impractical for typical classroom teachers to achieve.

The present research was based on the assumption that individualized adaptation could become feasible for classroom use when supported by computer-based instruction (CBI). Specific objectives of the strategy considered were to: (a) "personalize" verbal problem contexts for each individual; (b) orient the personalized contexts to diverse background and interest variables (e.g., hobbies, interactions with friends, etc.); and (c) automate the tasks of lesson preparation and administration. Theoretical support was provided, in part, from earlier research by Ross (1983) which demonstrated the effectiveness of adapting the contexts of examples presented in a statistics unit to college students' academic majors (also see Ross & Bush, 1980; Ross, McCormick, & Krisak, 1986). Nursing students performed best when the contexts concerned medical applications, whereas education students performed best when the contexts concerned teaching. The present strategy extended this orientation by adapting to the individual rather than to the group, and at the elementary school level.

For an illustration of the basic approach, consider the verbal problem presented in the bottom section of Table 1. Such a problem may not appear very unusual without knowing that only one student will experience it in that exact form. Specifically, the problem was uniquely constructed for a student named Steve whose best friends are Joe and Chris and whose favorite drink is cola. Other students would receive a structurally and thematically similar problem context, but the referents specified (the people and events) would be adapted to their personal experiences. We hypothesized that such personalized contexts would increase task motivation by describing applications of high interest to learners. We also expected them to improve comprehension by making it easier to interpret important information in the problem statements.

Insert Table 1 About Here

These assumptions were tested in two studies conducted with fifth- and sixth-grade students. In one study the presentation medium was CBI and in the other it was print material generated by the same computer program. Detailed descriptions of these studies are available in other sources (Anand & Ross, in press; Ross & Anand, in press). The purpose of the present paper is to discuss this research from a more applied perspective, while extending the findings to new analyses of the personalized model's effects on attitudes and performance. In a concluding section, it will describe our current efforts to develop a comparable CBI model appropriate for adapting word problems to individual students at the high-school or college level.

Study I: CBI Model

Several months prior to the study we met with the math teachers at the site elementary school to discuss the curriculum and identify any areas in which the children appeared to experience special difficulties. There was unanimous agreement that "division of fractions" was a definite problem area and an excellent topic for the development of supplementary materials. Using class materials and teacher suggestions, we designed a CBI lesson dealing with this topic. The adaptive component of that lesson and its evaluation are reviewed in the following sections.

Subjects and Design

Subjects were 96 fifth- and sixth-grade children representing approximately equal numbers of males and females, and of Blacks (n=50) and Caucasians (n=46). The students were randomly assigned to three treatments, in which personalized, concrete, or abstract contexts were used as the background themes for word problems. Major dependent variables were three achievement subtests used to assess different types of learning, task attitudes, and lesson completion time.

Materials

Biographical questionnaire. Prior to the study, students provided background information about themselves on a "biographical questionnaire." Among the categories included were homeroom teacher's name, birthdate, favorite relative, household pets, family's supermarket, favorite food, favorite restaurant, and friends' names.

Instructional unit. The math unit began with instructions and prerequisite math facts. The next section introduced and demonstrated the following four-step solution to dividing fractions: (a) identify the dividend and the divisor, (b) write the whole number as a fraction, (c) invert the divisor to obtain its reciprocal, and (d) multiply the dividend by the reciprocal of the divisor to obtain the answer. The rule application was then repeated for four additional problems, all containing an integer numerator and fraction divisor. The lesson was programmed in BASIC for use with an Apple IIe or compatible microcomputer.

Contexts were varied by altering the referents and background themes of the five example problems while keeping the numerical values and types of measurement units constant. Abstract contexts involved the use of general referents in problem statements, such as "quantity," "fluid," "liquid," and so forth, without a meaningful background theme (see top section of Table 1). Concrete contexts used specific standard referents, such as "Mary," "English," "an artist," and so forth to convey realistic but hypothetical applications (see Table 1, middle). Personalized contexts replaced abstract and concrete referents with personally familiar items obtained from the biographical questionnaire. The personalized information for a given student was entered on program DATA statements in a prescribed order, so that, for example, Value 1 was always birthdate, Value 2 was best friend's name, and so forth. In re-examining the example in Table 1, note that italicized words represent personalized referents selected for the given student ("Steve").

Achievement test. The achievement posttest consisted of 11 items, organized into a "context" section (1-6), "transfer" section (7-9), and "recognition" section (10-11).

Context problems were patterned after lesson examples, which involved dividing a whole number by a fraction. Two of the problems were presented in abstract contexts, two in concrete contexts, and two in personalized contexts.

Transfer problems differed from lesson examples in either contextual or properties. Specifically, Item 7 was structurally identical to lesson examples, but presented only numerical values without a verbal context. The two other transfer problems featured verbal contexts, but one involved dividing a fraction by an integer (Item 8) and the other a fraction by a fraction (Item 9). The problems used on one of two parallel sets were as follows:

7. 4 - 1/6 = ?
8. 3/4 of a cake was divided equally among 3 boys. How much of the cake did each one of them get?
9. Mrs. Perkins had 17/3 lbs. of candy. She put the candy into packages of 1/3 lb. In all, how many packages of candy did Mrs. Perkins make?

The two recognition items assessed memory of the rule statement and procedures using a multiple-choice format. Six parallel forms of the test were arranged and were randomly distributed to subjects. Internal consistency reliability was determined to be .79 using the KR-20 formula.

Attitude questionnaire. An eight-item attitude scale, using Likert-type ratings, was used to assess reactions toward certain properties of the task (e.g., clarity, sufficiency, relevancy, and others). The questionnaire concluded with an open-ended item asking students to describe their feelings about "having math problems of this type."

Procedure

Students who completed their regular mathematics units on addition, subtraction, and multiplication of fractions were considered eligible for the study. Each student completed the biographical questionnaire in class. Responses by those designated to serve in the personalized treatment were recorded on tabulation sheets in a prescribed order and entered in the computer in the form of program DATA statements. The "personalized" program was then saved on the disk using the student's name as a label. From one to three students were scheduled for a given learning session. Each completed the task at a separate computer. A proctor was available in the room to answer any questions about procedures.

Results

Treatment means on achievement subtests are summarized in Table 2 (see rows labeled "CBI"). A summary of statistical results for each dependent variable follows (for more details, see Anand & Ross, in press). The results reported were obtained from one-way ANOVA's following an initial MANOVA.

Insert Table 2 about here

Context subtest. Only the context treatment main effect was significant ($p<.01$). The personalized group was superior to the abstract group. Comparisons to the concrete context group were not significant.

Transfer subtest. On the two transfer items (#'s 7 and 9) that maintained fractions as divisors (as in the learning examples), the personalized group was significantly superior to both other groups (p's$<.05$). However, on the problem presenting an integer as a denominator, all groups performed at comparable low levels.

Formula recognition. The personalized context group was superior ($p<.01$) to the abstract context group; the concrete context group did not differ from either.

Other results. Total attitude scores were higher ($p<.05$) for the personalized context group than for the concrete context group; the abstract context group did not differ from either. Analyses of lesson completion times showed no differences between treatments. Nor were any differences found between boys and girls on any outcome variables. Analyses of aptitude-treatment interaction (ATI) effects, however, indicated that low performers on the math and reading subtests of the California Achievement Test derived relatively greater benefits from the personalized contexts than did high performers.

The experimental findings thus showed the personalized materials to be beneficial across a variety of learning outcomes as well as for attitudes toward the task. A question that arose in interpreting these effects concerned the importance of the computer's role in delivering the personalized materials. Would the materials have the same impact if presented in print form rather than by CBI? This question has practical importance considering that sufficient computer resources to support CBI may not be available at many schools. If a teacher could use one computer to generate individualized print lessons and produce comparable learning benefits, a desirable cost-effective option would be available. In our next study we examined the merits of such an approach.

Study II: Print Application

Study II replicated the design and procedures of Study I with one major change. The computer was used to generate print versions of the instructional material rather than to present the lesson. This approach eliminated the need for one-to-one student contact with a computer during learning, an important practical advantage.

Methods

Subjects were 54 fifth- and sixth-grade students selected from the same student population as the Study I sample. Subjects were randomly assigned, 18 per group, to the three context groups. All materials and basic procedures used for instruction and testing were the same as Study I. In the case of the abstract- and concrete-context treatments, standard instructional manuals were printed. For the personalized-context treatment, individualized manuals were prepared by entering the appropriate personalized data in the BASIC program and executing the program with the printer on.

Results

Similar to Study I, posttest results showed the personalized-context group to: a) surpass both other groups on context items ($p<.001$); b) surpass both groups on transfer items ($p<.01$); and c) surpass the concrete-context group on recognition items (for means, see rows labeled "Print" in Table 2). Transfer benefits again were realized only when the problem structure was the one experienced during learning (i.e., fractions as divisors). Finally, results from the attitude questionnaire showed the personalized group to view the examples as more understandable and more relatable to their interests (both p's $<.05$) than did the concrete group. On the total attitude score and nearly all items, the ordering of groups was personalized first, abstract second, and concrete third. No learning time differences were obtained; nor was sex a significant factor on any outcomes.

Follow-up Analyses and Current Research

To extend the above findings, we performed several new analyses of the Study I and Study II data, and have initiated an investigation of a related adaptive strategy designed for use with older students. These efforts are reviewed below.

Personalization Effect Sizes under CBI and Print Modes

Judging from Table 2, the CBI and print models produced a similar pattern of results. To enable a more precise comparison of findings, we computed effect sizes (Glass, 1976) for the personalized treatment on total attitude scores and on each of the achievement subtests. The effect size scores were derived by dividing the difference between the personalized group mean and the combined control group mean by the standard deviation of the combined control group. This measure, as commonly used in meta-analyses (Kulik, Kulik, & Cohen, 1980), allows findings from different studies to be consolidated and compared using the meaningful, uniform scale of standard deviation units. The present results show effects to be remarkably consistent across experiments (see Table 3), with the exception of the larger transfer benefits in the print study. In prior work, an effect size of .5 has been interpreted as "medium-sized" and one of .8 as "large" in magnitude and importance (see Cohen, 1969; Kulik, et al., 1980). Based on these standards, the impact of the personalized contexts in the two experiments would be judged quite substantial. The smallest effects were for attitudes (in the .5 - .6 range) while the largest were for context items and total posttest (in the 1.1 to 1.5 range). Assuming posttest scores to be normally distributed, the obtained differential would place the average student in the personalized group at close to the 90th percentile of the control group.

Insert Table 3 about here

Open Ended Responses

Students' open-ended reactions to the task indicated mostly favorable reactions in all treatment conditions. Several students indicated, for example, that although math was not a favorite subject, the clear and organized presentation made the lesson fairly easy to follow. Students who received the personalized examples, however, appeared to respond more positively and enthusiastically than did control group students. To verify this impression, a quantitative analysis was performed. Students' responses were typed on index cards and given to three independent raters to evaluate on a five-point Likert scale (e.g., 1="very unfavorable"; 5="very favorable"). The ordering of the responses was varied for raters by shuffling the cards for each. Raters saw only the protocols and were thus unaware of the respondents' identities or treatment conditions. Inter-rater correlations were relatively high, ranging from .82 to .88. The average ratings for each protocol were then analyzed by a 3(context) x 2(study) ANOVA using a regression solution to control for unequal n's. The context main effect was found to be highly significant, $F(2,96) = 8.24$, $p<.001$. Follow-up Tukey HSD tests showed the mean for the personalized-context group ($M = 4.33$) to be significantly higher than the means for the abstract ($M = 3.33$) and concrete-context ($M = 3.60$) groups. No other ANOVA effects were significant. A review of the reactions reveals that many students in the personalized group explicitly identified the examples as the key factor influencing their impressions. Interested readers may examine those responses in the Appendix.

Future Directions

Based on the aforegoing results we concluded that presenting problems in familiar contexts made materials more interesting and understandable for students. Whether the presentation mode was CBI or print had no bearing on performance. The CBI application offered the practical advantage of automation and greater control in presenting the lesson. The print application, on the other hand, allowed the adaptive lessons to be administered in regular classrooms without requiring one-to-one computer contacts.

Despite the positive results, some practical limitations of the overall strategy should be noted. First, even with computer support, preparing individualized lessons still requires extra time and effort by teachers. Second, it seems likely that the novelty of personalized examples would significantly diminish over repeated uses. These considerations suggest restricting applications to the one or two course topics considered most difficult or least intrinsically interesting. Another limitation concerns the age level of the target student groups. Specifically, problem contexts describing one's teachers and friends may appear a little contrived and not very stimulating for those beyond the elementary school grades. Older students (including adults), however, do appear to have strong individual preferences for general themes, such as sports, politics, cooking, and so on (Ross et al., 1986). Based on this idea, we are currently developing an adaptive CBI lesson that allows students to select the themes for example problems at the beginning of each problem-solving exercise. The present lesson is a statistical unit on central tendency and the theme options are sports, business, education, and numerical. Evaluation of the "theme selection" strategy will involve its comparison to conditions offering standard themes and "mismatched" (non-preferred) themes. The theme-variations will in turn be crossed with parallel conditions involving selection of the number of practice examples received. An interesting question that has not been investigated in prior research is whether students will elect to receive more examples when preferred themes are represented, and vice versa.

In a recent pilot test of the materials and computer program, 17 undergraduate education majors completed the lesson under the theme-selection strategy with a fixed quantity of examples. When asked in a follow-up survey if the availability of familiar themes increased understanding, 1 student disagreed, 4 were undecided, and 12 agreed or strongly agreed. The student who disagreed, however, reacted positively to the opportunity to select a preferred theme by writing "... it allowed me to take the numerical context which contained the least distraction since I needed clarity and simplicity for understanding." Other reactions were: "I was able to use something of interest..."; "I learned better as it made it more applicable"; "Interested in education (themes)...enjoyed them"; "I was glad that I could choose different themes...made the computer (lesson) more interesting"; "I like it because I could pick my subject." Interestingly, the theme selections were highly varied both between and within individuals, with nearly all students selecting at least two different themes across the five problem-solving sections. A more formal test of the theme-selection strategy will take place in several controlled experiments planned for the coming year. The major hypotheses is that the strategy will enhance learning by helping students to relate the statistical concepts taught to familiar events. As followers of J. F. Herbart would probably agree, this is an old ieda given new possibilities through modern day computer technology.

References

Anand, P., & Ross, S.M. (in press). Using computer-assisted instruction to personalize math learning materials for elementary school children. *Journal of Educational Psychology.*

Ausubel, D.P. (1968). *Educational psychology: A cognitive approach.* New York: Holt, Rinehart, & Winston.

Berliner, D. (1986). Use what kids know to teach the new. *Instructor,* March, 12-13.

Chi, M., Feltovich, P., & Glaser, R. (1981). Categorization and representation of physics problems by experts and novices. *Cognitive Science*, *5*, 121-152.

Chi, M., Glaser, R., & Rees, E. (1982). Expertise in problem solving. In R. Sternberg (Ed.), *Advances in the psychology of human intelligence.* Hillsdale, NJ: Erlbaum.

Cohen, J. (1969). *Statistical power analysis for the behavioral sciences.* New York: Academic Press.

Daruwalla, A. (1979). *A study of the effectiveness of the use of the newspaper in the classroom on student achievement in 7th grade mathematics.* Unpublished doctoral dissertation, Memphis State University.

De Corte, E., Verschaffel, L., & De Win, L. (1985). Influence of rewarding verbal problems on children's problem representations and solutions. *Journal of Educational Psychology, 77,*406-470.

Dreyfus, H., & Dreyfus, S. (1986). Why computers may never think like people. *Technology Review*, January, 43-61

Glaser, R. (1984). Education and thinking. The role of knowledge. *American Psychologist, 39,* 93-104.

Glass, G.V. (1976). Primary, secondary, and meta-analysis of research. *Educational Researcher, 10,* 3-8.

Jones, B.M. (1983). Put your students in the picture for better problem solving. *Arithmetic Teacher, 303,* 30-32.

Knifong, J.D., & Burton, G.M. (1985). Understanding word problems. *Arithmetic Teacher, 32,* 13-17.

Kulik, J.A., Kulik, C-L. C., & Cohen, P.A. (1979). A meta-analysis of outcome studies of Keller's personalized system of instruction. *American Psychologist, 34,* 307-318.

Marshall, S.P. (1984). Sex differences in children's mathematics achievement: Solving computations and story problems. *Journal of Educational Psychology, 76,* 194-204.

Mayer, R.E. (1975). Information processing variables in learning to solve problems. Review of Educational Research, 4, 525-541.

Mayer, R.E. (1982). Memory for algebra story problems. Journal of Educational Psychology, 74, 199-216.

Muth, K.D. (1984). Solving arithmetic word problems: Role of reading and computational skills. Journal of Educational Psychology, 76, 205-210.

National Assessment of Educational Progress. (1979). Second assessment of mathematics: Mathematical applications. (Report No. 09-MA-03). Denver, CO: Educational Commission of the States.

Riley, M.S., Greeno, J.G., & Heller, J.I. (1983). Development of children's problem-solving ability in arithmetic. In H.P. Ginsburg (Ed.), The development of mathematical thinking. New York: Academic Press.

Rosen, D.R. (1984). Students schemata for algebra word problems. Paper presented at the annual meeting of the American Educational Research Association, New Orleans.

Ross, S.M. (1983). Increasing the meaningfulness of quantitative material by adapting context to student background. Journal of Educational Psychology, 75, 519-529.

Ross, S.M., & Anand, P. (in press). A computer-based strategy for personalizing verbal problems in teaching mathematics. Educational Communication and Technology Journal.

Ross, S.M., & Bush, A.J. (1980). Orienting statistics instruction for teacher candidates to classroom applications. Journal of Educational Research, 74, 19-23.

Ross, R.M., McCormick, D., & Krisak, N. (1986). Adapting the thematic context of mathematical problems to student interests: Individual versus group-based strategies. Journal of Educational Research, 79, 245-252.

Shuell, T. J. (1987). Cognitive conceptions of learning. Review of Educational Research, 56,(4), 411-436.

Wright, J. P., & Stevens, N. K. (1983). Improving verbal problem-solving performance. Arithmetic Teacher, 31, 40-42.

Zweng, M.J. (1979). The problem of teaching story problems. Arithmetic Teacher, 27, 3-4.

Table 1

CBI Study

They (examples) were very easy to understand and remember. They were very good.

Surprised with my name and everything...They are a lot more funny than regular problems.

...I didn't first know them, but now I think Iw many containers can we fill with the 4 quantities of fluid?

Concrete Context

Mike had 4 bottles of juice to pour into cups. He pours 2/3 of a bottle of juice into each cup. How many cups can Mike fill with the 4 bottles of juice?

Personalized Context

*Joe,Chris,*and other friends visit *Steve* on a weekend. *Steve* has 4 bottles of *cola* in his refrigerator. He pours 2/3 of a bottle of *cola* into each cup. How many cups can *Steve* fill with 4 bottles of cola?

Italicized words indicate personalized referents that were varied for each student.

Table 2

Treatment Means on Achievement Subtests in the CBI and Print Studies

	Context Treatment			
Subtest and Study	Abstract	Concrete	Personalized	
All Subject				
Context (6)				
CBI	1.38	2.38	4.00	2.59
Print	1.61	1.45	4.45	2.50
Transfer (3)				
CBI	.33	.42	.75	.50
Print	.33	.39	1.16	.63
Recognition (3)				
CBI	.50	.79	1.21	.83
Print	1.22	.78	1.39	1.13
Total (11)				
CBI	2.28	3.58	5.96	3.94
Print	3.17	2.61	7.11	4.30

a. Values in parentheses indicate number of items on subjects
b n=24 in each treatment
c. n=17 in each treatment

Table 3

Effect Sizes for the Personalized Treatment in CBI and Print Studies

Dependent Measure	Study	
	CBI	Print
Context	1.10	1.48
Transfer	.59	1.27
Recognition	.78	.48
Total Posttest	1.23	1.50
Attitude Total	.64	.49

Appendix
Open-Ended Reactions Referring to Personalized Examples

CBI Study

They (examples) were very easy to understand and remember. They were very good.

Surprised with my name and everything...They are a lot more funny than regular problems.

...I didn't first know them, but now I think I understand them. It made me understand these better with my name on it.

...They are more related to me and I can understand these.

I reacted very strongly because I have never seen the problems this way. ...they (examples) were easy to understand... It was very fun.

...It (example) could help others understand math better.

I thought I would not understand, but I did understand a lot. I was surprised to see my friend's name.

I was surprised because they were using my name in these situations. I could easily relate to the problems...

It was kind of interesting and understanding examples.

Print Study

I was surprised. Usually questions are the same for everyone...

I thought it was fun. Because my teacher gave me something and I do have a pet Smoky.

I though it was great to see the names of people I know. I could relate to the problem. I really liked hearing the names of my friends and my dog.

I was surprised to see my name in it and I thought it was very interesting...

Surprised they know that much about me. Good. You would be in the situations.

I was interested in what was going to happen next. You would be more interested in reading them.

Good because they (examples) make it more understandable...

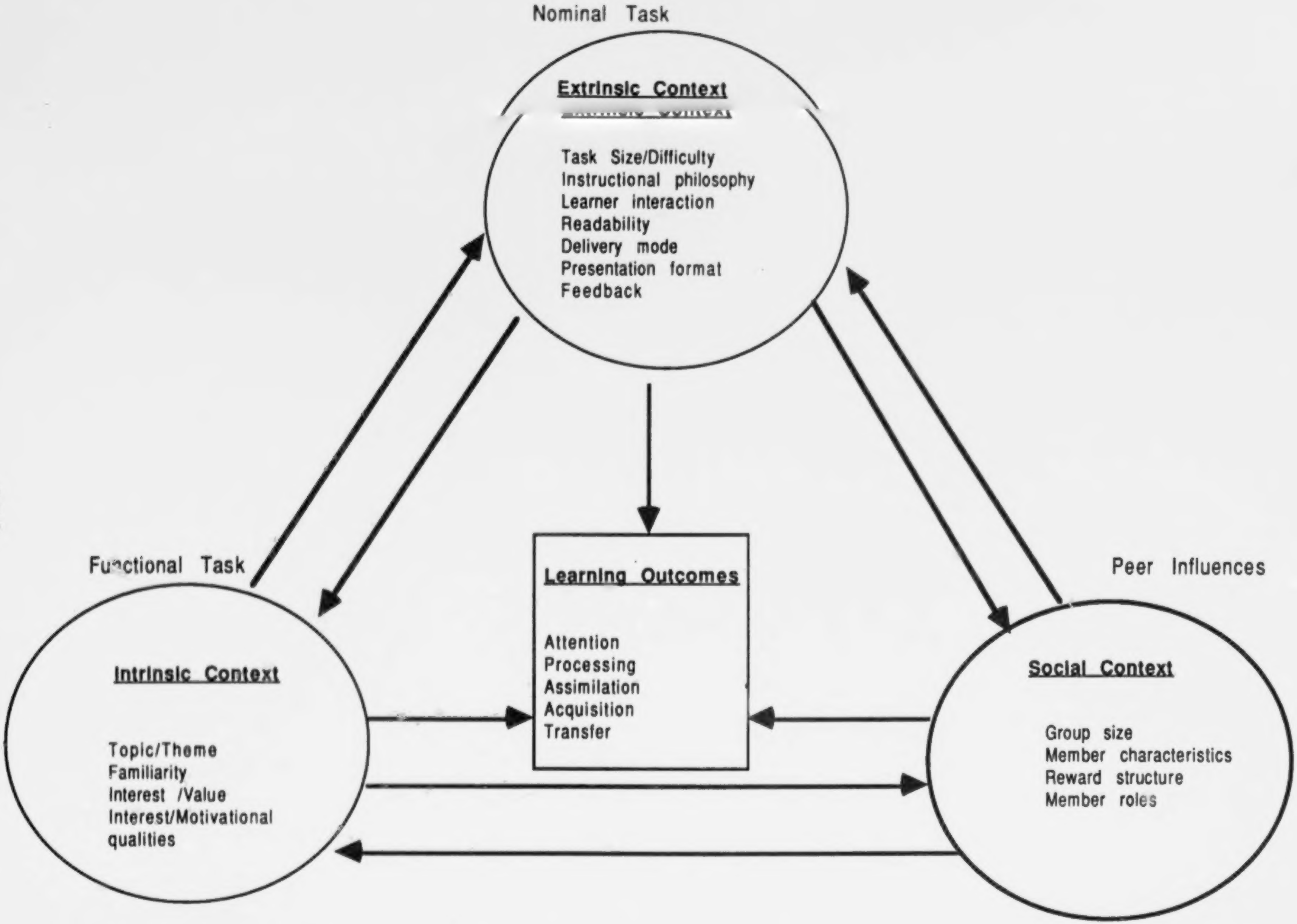

Nominal Task
Extrinsic Context
Task Size/Difficulty
Instructional philosophy
Learner interaction
Readability
Delivery mode
Presentation format
Feedback
Functional Task
Learning Outcomes
Attention
Processing
Assimilation
Acquisition
Transfer
Peer Influences
Intrinsic Context
Topic/Theme
Familiarity
Interest /Value
Interest/Motivational qualities
Social Context
Group size
Member characteristics
Reward structure
Member roles

Figure 1: Contextual factors affecting CBI

RESEARCH IN DISTANCE EDUCATION; A SYSTEM MODELING APPROACH

Farhad Saba, Ph. D.
Associate Professor
Department of Educational Technology
San Diego State University

David Twitchell
Graduate Student
Department of Educational Technology
San Diego State University

Association for Educational Communication and Technology
Research and Theory Division

Atlanta

February-March 1987

INTRODUCTION

This presentation will demonstrate a computer simulation research method based on System Dynamics modeling technique for studying distance education systems. The presentation will include:

- a brief review of research methods in distance education,
- rationale for systems research in distance education,
- technique of model development using System Dynamics approach and the DYNAMO simulation language.
- display of a computer simulation of a prototype model.
- audience participation in changing critical variables in the prototype model to observe related changes in the model's behavior.

RESEARCH METHODS IN STUDYING DISTANCE EDUCATION SYSTEMS[1]

Published research in the field of distance education covers two broad categories of conceptual studies and case studies:

Conceptual studies- Literature related to concepts of distance education have served at least three purposes. They have:

- offered definitions for the field,
- provided conceptual models for various systems and,
- presented current and future trends in the field.

For example, Keegan (1980), analyzed several definitions of distance education suggested by experts in the field, and discussed their conceptual, organizational and social ramifications. Furthermore, Keegan (1980) and Holmberg (1981) have delineated the purpose of distance education as follows:

- to eliminate time and distance constraints in the delivery and utilization of educational services,
- to provide educational services to those unable to participate in conventional learning, and
- to provide continuing education to adults who wish to acquire new skills and knowledge.

Pery (1977) provided a detailed account of the British Open University (BU). Besides its own merits Pery's work is significant in that BU has been emulated in several parts of the world as a viable model for developing new distance education organizations. Zigrell (1984) reviewed distance education systems in the United States and presented a pragmatic approach to the field that is based on student needs, available delivery systems and economic realities.

---

[1] Distance education is a relatively new term for a field that has encompassed educational broadcasting, as well as non-electronic means of disseminating educational information. In this presentation, the term distance education includes electronic as well as non-electronic means of reaching learners in diverse geographic locations.

Case studies- In studying distance education systems researchers have relied heavily on the **case study** method of inquiry. In such studies either the entire structure of a distance education **system** has been analyzed, or a particular function is selected for analysis. In most case studies at least one or all of the following functions within a structure are analyzed:

- Social context and the governance of the system,
- Administration and organization,
- Modes of communication,
- Instructional (curriculum) development,
- Production, distribution and utilization,
- Attitudes towards the system and
- Learners and learning outcomes.

For example, Mayo and Hornik (1976) provided a comprehensive study of the educational television system in El Salvador. Schramm, Nelson and Betham (1981) studied the educational television system in American Samoa. Concentrating on higher education's use of distance education, Harry and Rumble (1982) edited an anthology in which case studies on several countries were presented. These included the U.S.S.R., the United Kingdom, the United States, and the People's Republic of China.

In case studies that are concerned with a distance education system in its entirety, as well as those studies that are only concerned with a specific function within a system, different methods of inquiry have been employed to learn about each function. For example:

- descriptive analysis is used to show how distance education systems are organized and governed.
- cost-benefit analysis is used to study financing and budgeting of systems,
- course evaluation methods are used to study curriculum effectiveness,
- survey methods are used to study utilization patterns and user attitudes towards the system,
- experimental research methods are used to study learners and to measure learning outcomes.

RATIONALE FOR SYSTEM RESEARCH IN DISTANCE EDUCATION

The research methods outlined above, while provide information about each functions of a distance education system, do not shed any light on the relationships among these functions. For example, descriptive studies show different organization structures and governance practices, and experimental studies show how well learners learn through distant means. But neither of these methods, nor other methods mentioned above provide any information about the relationship between how a system is organized and governed and how well learners learn. System research provides four critical types of information that may not be readily attainable through the use of other research methods. They are:

- how one part of the system affects the other parts and is affected by the other parts.

- how each part as well as all parts, collectively, help or hinder the system to achieve its goals.
- how the system interacts with its social context (environment.)
- what alternative policies move the system toward its goals in the future.

For example, systems research can produce information on how the governance and financing of a system may affect instructional development, production, dissemination and learning outcomes within a system. Or how increased or decreased learning outcomes may affect financial and political support for the system (through its governance function) that in turn affects all the other parts of the system.

Furthermore, system research can provide information on how each system is affected by changes in its environment: How social change, political change or economic development as a whole may affect the behavior and the life of a distance education system. Using system analysis one can delve into questions such as how distance education systems could be affected by:

- demographics of a society (aging of a population, change in ethnic composition of a society, etc.) and/or;
- political mood of a society (rise in conservatism, isolationist attitudes etc.) and/or;
- economic developments (increase in high-tech manufacturing, fluctuating cost of transportation , etc.)

In addition, systems research and particularly System Dynamics assist evaluators, managers and personnel of an organization to:

- explicate their assumptions and perceptions about goals objectives, policies and.future plans
- articulate their assumptions, and perceptions in precise terms.
- share their assumptions, and perceptions with colleagues in public.
- modify their assumptions and perception to reach organizational goals more effectively, and efficiently.

Distance education as a system- In recent years, social scientists have used the concept of general systems theory and related modeling methods for understanding complex social phenomena and for designing new organizations (Ackoff and Emery 1972, Forrester, 1972, Churchman 1979, Roberts, et. al., 1983, Wilson 1984). In the field of distance education systems research has been minimal. Saba and Root (1976) used System Dynamics methods to design and simulate a distance education system in the Middle East. Vazques-Abad and Mitchell (1983) used system modeling concepts to develop an economic evaluation model for distance education projects.

Realizing the paucity of system research in educational technology in general Heinich (1984) called for an increased use of systems analysis techniques for learning about education and for designing new organizations for educational purposes. If applied to distance education, system analysis could assist educators to:

- understand the comprehensive structure of distance education;
- identify critical functions of distance education;
- predict and control the intertwined relationships among the functions of a distance education system;

- determine the optimal performance of a distance education system for serving its clients (learners, parents, etc.);
- determine the impact of environmental changes on a distance education system and the impact of the system's performance on its environment.
- design more effective and efficient distance education systems.

SYSTEM DYNAMICS

Description and applications- System Dynamics is a technique for translating intuitive models into causal-loop diagrams in which the effect of one system function on other affected functions are clearly depicted through positive or negative feedback loops. Based on such feedback loops or causal-loops, flow diagrams are developed in which each system function is shown in terms of a level or a rate of performance. The technique provides for translating the flow diagram into a set of more formal mathematical equations in DYNAMO: a simulation language.

System Dynamics allow objective observation of each system function in terms of its present level of performance and the rate in which this level is decreased or increased through time. DYNAMO is capable of plotting the performance of each system function and the performance of the system as a whole in specific time intervals in the future. Objective observation of system functions is not limited to collection of statistical data on rates or, levels of system variables. The strength of this technique is that it allows for inclusion of underlying assumptions about how system functions behave, or how they should behave. These assumptions that are made by the personnel in charge of system functions, are not overlooked, and are included as key elements in developing system diagrams and writing equations to represent these diagrams.

This method has been used to study a variety of social phenomena, organizations and systems ranging from the future of the world (Forrester 1961) to industrial relations, ecological systems and the growth and decay of cities. (Meadows & Robinson 1985.) If applied to research in education, it is a versatile research method that can provide much needed information on how educational systems are affected by the nature of their own structure and organization as well as their contextual environments.

Technique of model development- Roberts et al (1983) suggests six steps for model development using System Dynamics:

1- Identifying a problem and conceptualizing a system model representing the problem.

2- Developing a casual-loop diagram of system functions.

3- Developing a flow diagram based on the casual-loop diagram.

4- Developing a set of DYNAMO equations representing the model.

5- Running and testing the model.

6- Evaluating policy options in relation to the problem and in light of the results of the simulation.(pp. 8)

The same steps were followed in developing this simulation exercise.

1- The Problem

Hawkridge and Robinson (1982) studied twelve educational broadcasting systems in Africa, Asia, Europe, South America and the United States and observed that distance education systems receive their funding from a variety of sources. They found that some systems are funded by federal, regional or local governments, while others receive their funds from student fees or private donations. All observations, however, showed that financing of the system was a very influencial factor in how the system is managed. These observations led Hawkridge and Robinson to recommend that:

> a) Managers should carry out detailed analyses of sources of financing for educational broadcasting, to avoid neglecting potential sources, and
>
> b) In the same way, they should carry out cost analyses based on functions (for example general administration, conception, production, distribution, utilization, evaluation) to enable them to determine the balance of resources allocated to each function and whether this is the correct balance. (pp. 149-150).

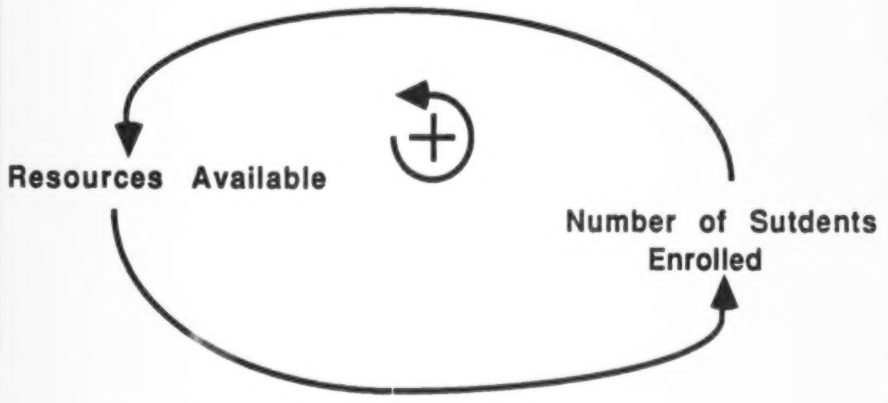
These recommendations provided the framework for formulating two basic questions for the simulation exercise:

a) Does the initial number of students enrolled in a distance education system affect the resources allocated to the system?

b) How do resources available to the system affect the performance of each system function?

2- The Causal Loop Diagram.

To answer these questions, by developing a casual-loop, we assumed a positive feedback loop between the number of students enrolled in a system and the amount of resources made available to the system; that is the more individual students pay to take telecourses, the more money available for that system. And the the more resources made available to the system, the greater the number of students that can be served by the system. This assumption defines the purpose of a distance education system: To use its resources to **reach as many members of its intended audience as possible** to enhance their learning. Diagram No. 1 demonstrates this basic relationship.

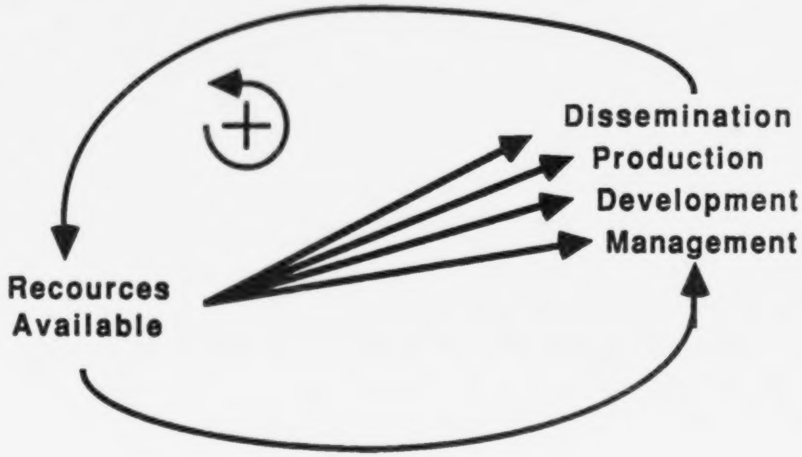


Causal Loop Diagram No.1

The next step in further development of the causal loop diagram was to determine the **basic functions** of a distance education system, since our second question is how resources available to a system affect the performance of its different functions. The literature survey showed that while, the structure of educational broadcasting systems differ greatly, most systems possess the minimum functions required for fulfilling their purpose. Most organization charts depicted by Hawkridge and Robinson (1982) included the following essential functions:

- management and administration,
- instructional development,
- media production and
- dissemination of instructional information.

The causal loop diagram, therefore, was augmented to show that resources available to a distance education system support its basic functions of organization development, instructional development and production. Instructional programs developed through these functions are made available to the learner by another function which is dissemination. An intuitive assumption was that programs disseminated affect the number of students enrolled, which in turn affect the level of resources available to the system.



Causal Loop Diagram No. 2

Simplicity was a basic criteria in developing the system model at this stage, therefore, several intervening functions were left out of the diagram. For example, resources made available to a system may be affected by other elements in addition to the number of students enrolled. The wish of a community to support a distance education system, regardless of the number of students enrolled, may be instrumental in increasing or decreasing the rate of resources allocated to a distance education system. It is also reasonable to assume that the number of students enrolled may be affected by instructional support services. That is, the more instructional support services offered to students, the higher the number of students who would be willing to receive educational services from a distance education system. These examples contain crucial environmental variables in distance education projects. These functions are extremely important and should be included in more complex models.

3- The Flow Diagram.

A flow diagram was developed based on the causal-loop diagrams to further explicate and formalize the assumptions for model development. A prose description of the flow diagram follows:

The *level* of available resources to a distance education system at the present time (RESAV .K) is assumed to be affected by a steady *rate* of monetary allocations (RESAL) from *funds* that is dependent upon the number of students enrolled. The *rate* of expenditure (RESSPT) is increased or decreased by four functions or *auxiliaries* : organization development (ORGD), instructional development (DEV) and production (PROD). It is assumed that these auxiliaries control the rate of a fourth auxiliary which is dissemination (DISS). Dissemination in turn controls the rate of enrollments (ENROLL) and the rate of enrollments affect the level of student population at the present time (STPOP .K). In addition, this level is affected by another rate which reflect the students who graduate or drop out of the system. Student population at the present time influence an auxiliary or *funds* which in turn controls the rate of resources allocated to the system.

4- Equations for the Model.

The following equations were developed to represent a mathematical formulation of the flow diagram:

Insert the equations about here.

The following is a prose description of the model to make the model assumptions more clear:

Dynamo Distance Education Simulation Description of Terms

RESAV	This represents the level of money available for use in meeting working expences. (Resources available)
RESAL	This represents the rate of funding to the whole distance education process. (Resources allocated)
RESSPT	This is the rate of expenditures. (Resources spent)

T=48	Three years or 48 months is the time allocated to the simulation. This is an arbitrary figure, yet a resonable time to determine wheather or not a projection is reflecting reality.
PROD	The production costs: printing, footage, talent and other working, production expences.
PRODIN=0.1	This is the percentage of resources available used for production during each time frame (1 month).
DEV	The development costs: research and instructional development.
DEVIN=0.05	This is the percentage of resources available used for development during each time frame (1 month).
ORGD	This represents the organizations management budget: salarys, office expences, administration expences ect..
ORGDIN=0.05	This is the percentage of resources available used for management and administration during each time frame (1 month).
ACBUDJ	This is the total accumulated budgets: Production,Development and Organization Management.
DISS	This is the cost of disseminating instruction: equipment, power, maintenance, etc.. (The total dissemination is dependent upon the accumulated budgets.)
DISSIN=0.2	The percentage of resources available used for the dissemination of an instructional product.
STUPOP	This represents the level of student population or the number of students currently receiving services (instruction) from the system.
ENROLL	This is the rate of enrollment. The rate at which students begin to use instructional services.
ENROFR	This is the enrollment fraction table showing theprojected effect of enrollment. Table figures are based on estimated expenditures.
TENROL	This is the enrollment fraction based upon tabular data.
FROTOP	This represents the fraction of the total population that are students receiving instruction.
TOTPOP= 500	A total population amount.
GRDROP	This is the rate at which students exit the student population and are not receiving instruction.
STUPOP=25.00	This is the inital number of students in the studentpopulation. This is a seed number and will be manipulated by the calculations in the porgram.
FUNDS	The level of funds going into the resources available. Funding is dependent upon the student population.
DOLPER=10	The cost of instruction per/student. (dollar/per/student) .

5- Running the Model.

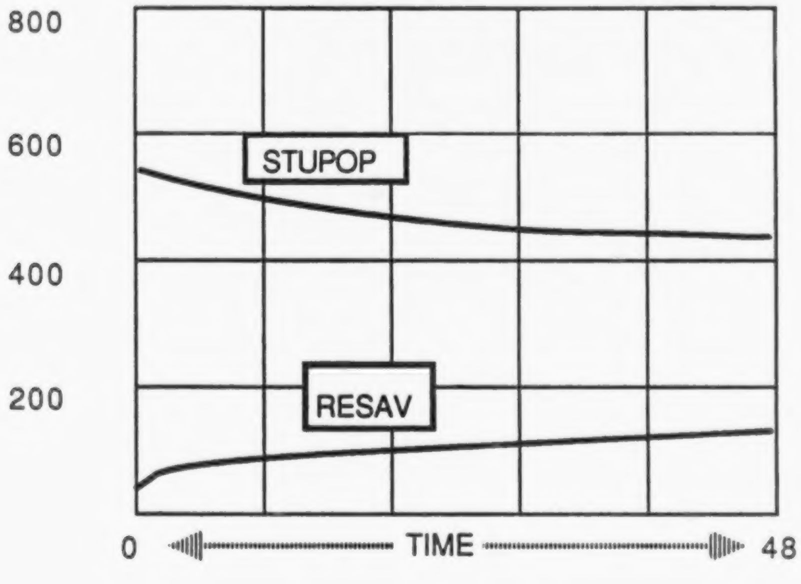
Several runs were made to test the equations and debug the formulas. Then the model was run under two different initial enrollment levels. The first run of the model represents a student population of 75 out of a total potential student population of 500 (or 15%). Under this condition in a 48 month period the following changes in the behavior of the model were observed:

- the level of resources available to the system declined and continued to decrease, while the level of student population increased moderately (slightly surpassing 100) and then started to level off. (See Plot No. 1.1.)

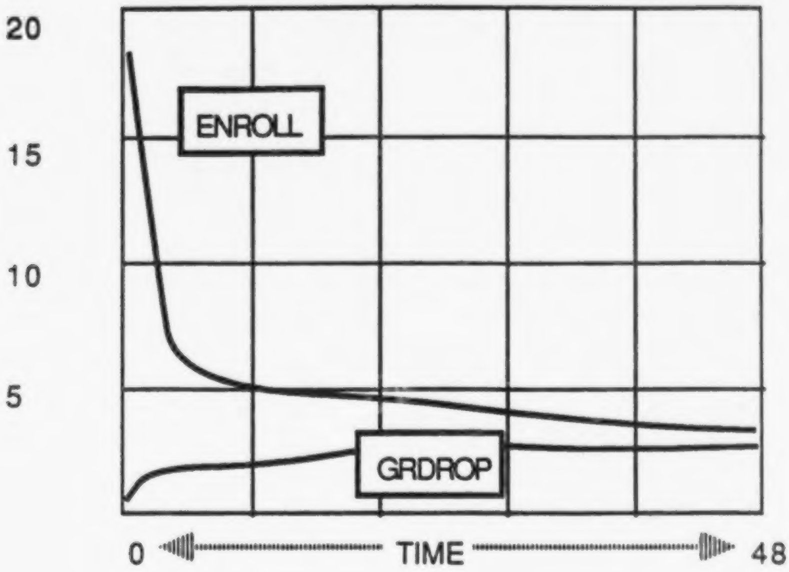
- there was a dramatic decline in the rate of enrollments in the first six months of the operation. The decline was not as dramatic after this period, but it did continue to do so. The rate of graduation slowly increased in the first year and then it slowed down to approach the same value as the rate of enrollments. (See Plot No. 1.2.)

- the functions also declined throughout the time of the simulation. The most dramatic was the rate of production which showed a steady decline throughout the 48 months. All other functions, instructional development, organization development and dissemination also declined toward zero.(See Plot No. 1.4.)

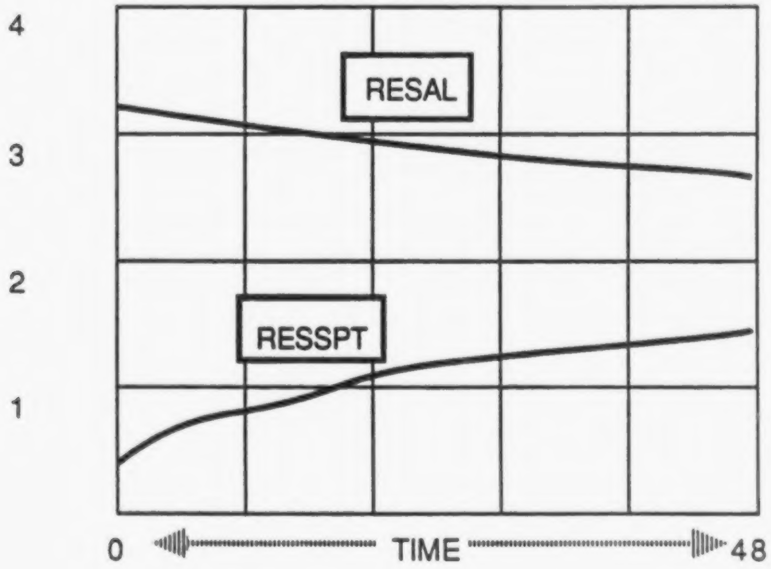
PLOT NO 1.1

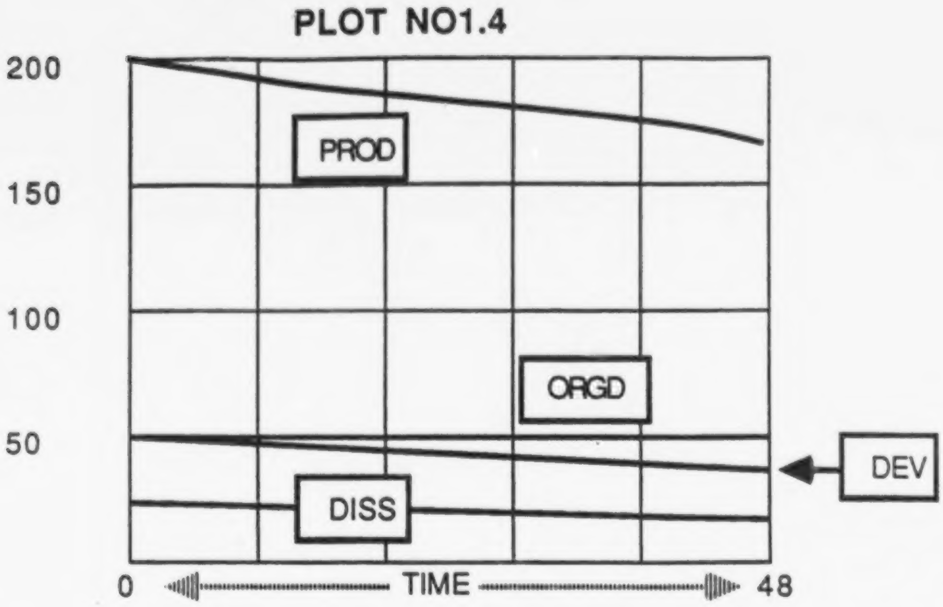


PLOT NO 1.2



PLOT NO 1.3





For the second run of the model the initial student population was changed to 100 to represent 20% of the total population. Under this condition it was observed that:

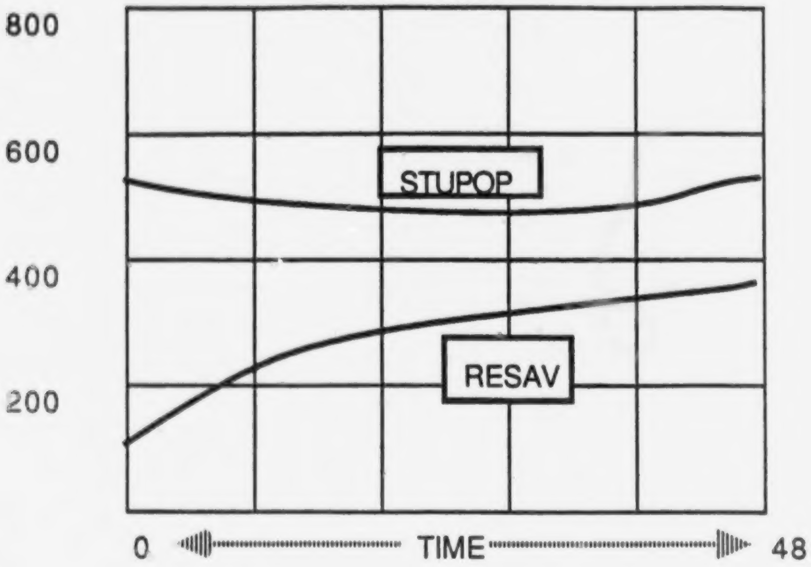
- the level of available resources declined slightly in the first few months, but then it went back to its initial value and stayed there for the rest of the time. The level of student population, however, showed a dramatic increase to almost include the total population near the 48th month. (See Plot No. 2.1.)

- the rate of enrollments showed a decline during the first two years of the operation, while the rate of graduation increased during this time. As it could be expected, both rates showed a tendency to approach the same value in the future. (See Plot No. 2.2.)

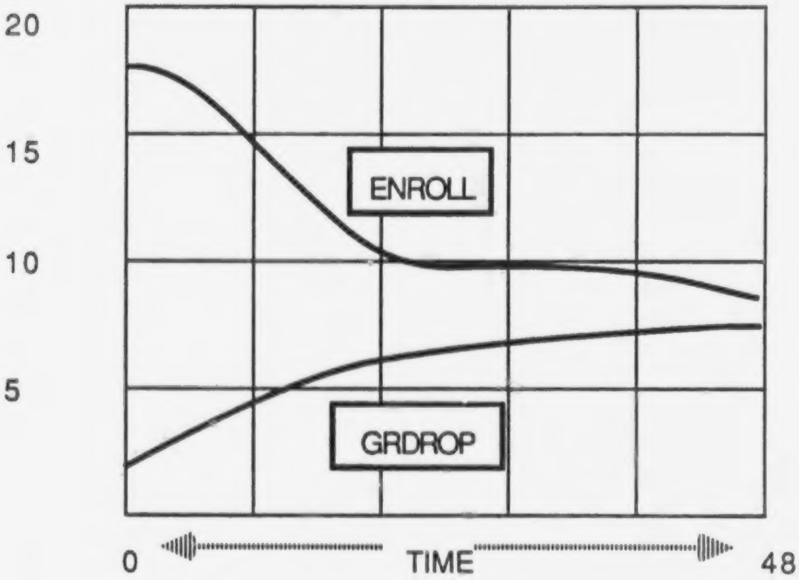
- the rate of resources allocated decreased slightly in the first half of the simulation, but then the rate went back to its initial value, and remained there. Whereas, the rate of expenditure showed a dramatic increase during the first 18 months, and although it began to slow down, it still remained at an impressive value. (See Plot No. 2.3.)

- the rate of functions experienced healthy values in this run. Production declined slightly during the first half of the simulation time, then it increased to regain its initial value. Instructional development, organizational development, and dissemination, however, kept the same rate of performance during the entire time. (See Plot No. 2.4.)

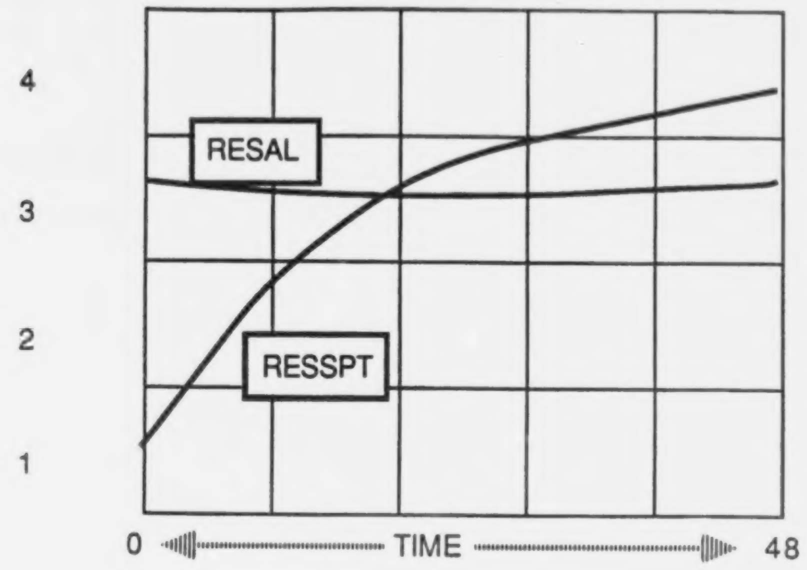
PLOT NO 2.1



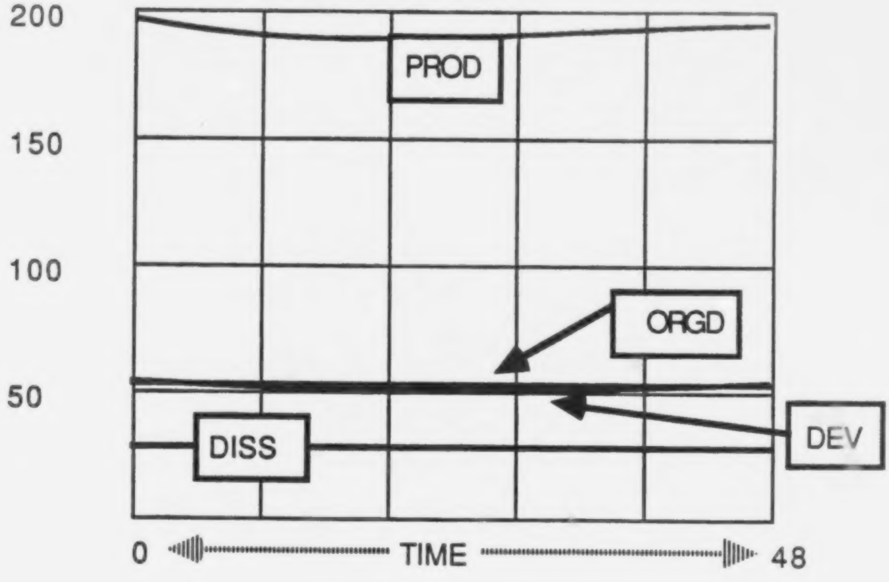
PLOT NO 2.2



PLOT NO 2.3



PLOT NO 2.4



DISCUSSION

The two initial values in student enrollment had different impacts on the resources made available to the system as well as on the behavior of its four functions. Starting with a student population of 75, or 15% of the total population and an initial available resource of $500 (where cost per student is $10), resources available to the system declined to almost $400 in 48 months. Whereas, with an initial student population of 100, resources available declined slightly to $475, but went back to its original value at the 48th month.

In the first scenario all four functions declined during the 48 months. As the system grew older the rate of resources allocated to organization development, instructional development, production, and dissemination sloped downward. Student population increased during the first few months of the simulation but , did not go beyond 100 students or 20% of the total population. In contrast, with the initial student population of 100 all four functions showed a steady rate of performance. Their rate neither increased nor decreased, except for a slight decrease in production; only for it to regain its initial value later on. Enrollments, however, did increase to include 400 students or 80% of the total population.

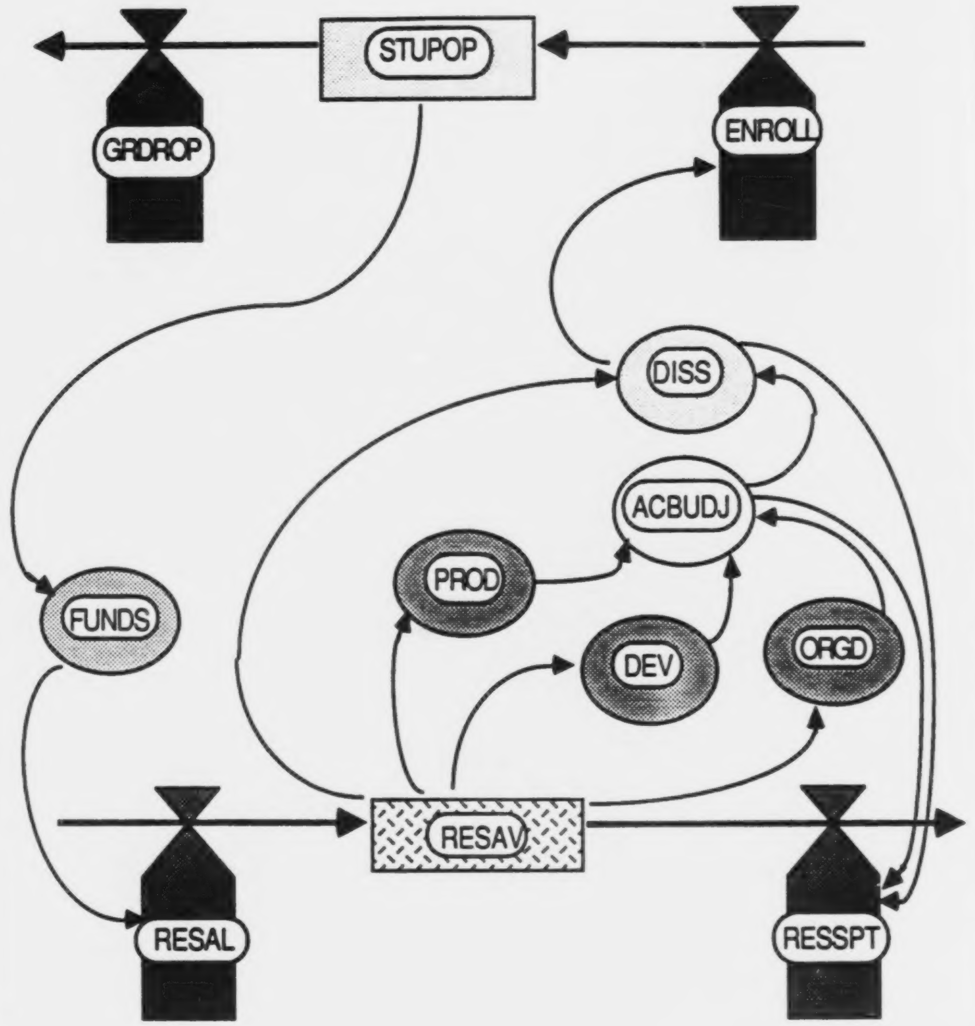
In this exercise, the second scenario showed a viable distance education system, which would be expected to function at least for four years, with healthy enrollment levels (80%) and rates of performance in its organization development, instructional development, production and dissemination functions. Whereas, the first scenario showed a system that would experience low levels of student enrollments (20%) and declining rates in all of its four functions. It is more likely for a system operating under the second scenario to grow and prosper, but less likely for a system to continue a healthy life under the assumptions of the first scenario. The behavior of the system under the first set of assumptions provide reasons for its managers to intervene and attempt to change one, or a few of the key factors to make it a more viable operation. The scenario under the second set of assumptions provide information about the kind and the degree of changes that would be necessary to make a system more viable.

CONCLUSION

The objective of this simulation exercise was limited to the demonstration of System Dynamics as a tool for research and organization development. It was specifically limited in scope in two respects:1) It did not represent a real referent in so far as its assumptions were not based on observation of an operating distance education system. 2) The model neither included the influence of environmental elements on the "internal" functions of the system, nor was it concerned with the impact of the system on its environment. Many elements such as the will of the community, the effects of a support sub-system on enrollments etc., were left out at this stage.

To develop and simulate a more realistic model, assumptions reflected in the model should represent factual information from an operating distance education system. Such factual information should not be limited to statistics on expenditures, enrollments etc., but should reflect the assumptions of the key personnel in charge of functions, budgeting and planning. A main purpose for using System Dynamics is to make assumptions and perceptions of the people concerned about a system precise and public, so that they may be criticized and improved in the future.

In addition, a more complex model should be developed to reflect environmental factors, such as public expenditure on education, community policies, needs of employers, geographical factors, etc. A more complex model will help to enhance our understanding of the role of distance education in its societal context.


STUPOP
GRDROP
ENROLL
DISS
ACBUDJ
PROD
FUNDS
DEV
ORGD
RESAV
RESAL
RESSPT

System Dynamics Flow Diagram for Simulating a Distance Education System

REFERENCES

Ackoff, R., & Emery, F. (1981). On Purposeful Systems. Chicago IL: Aldine, Atherton.

Churchman, C. W. (1968). Systems approach. New York, NY: Dell.

Forrester, J. W. (1961). Industrial dynamics. Cambridge, MA: MIT Press.

Harry, K., & Rumble, G. (1982). The distance teaching university. New york, NY: St. Martin's Press.

Hawkridge, D., & Robinson, J. (1982). Organizing educational broadcasting. London: Croom Helm.

Heinich, R. (1984). The proper study of instructional technology. Educational Technology and Communication Journal, 32 67-87.

Holmberg, B. (1981). Status & trends of distance education. London: Kogan Page Limited.

Keegan, D. (March, 1980) On defining distance education. Distance Education, 1 (1), 13-36.

Mayo, J. Hornik, & R. McAnany, E.. (1976). Educational reform with television: The El Salvador experience. Stanford, CA: Stanford University Press

Meadows, D. H., Robinson, J. M., (1985). The electronic oracle. Chichester, Great Britain. John Wiley & Sons.

Pery, W. (1977). The Open University. San Francisco, CA: Jossey-Bass.

Saba, F., & Root, G. (1976). Educational television: A new frontier. Proceedings of the International Conference on Cybernetics and Society, IEEE, (pp. 111-114). Washington, DC.

Schramm, et. al. (1981). Bold experiment: The story of educational television in American Samoa. Stanford, CA: Stanford University Press.

Roberts, N. et. al. (1983). Introduction to computer simulation. Reading, MA: Addison-Wesley.

Wilson, B. (1984). Systems: Concepts, methodologies, and applications. New York, NY: John Wiley and Sons.

Vazquez-Abad, J. & Mitchell, P. D. (August, 1983). A systems approach to planning a tele-education system. Programmed Instruction & Educational Technology, 20, (3). - .

Ziegrell, J. (1984). Distance education: An information age approach to adult education. Washington, DC: Instructional Telecommunication Consortium. American Association of Continuing Education of Community and Junior Colleges. (ERIC Document Reproduction Service No. ED 246 311)

```
*       DISTANCE EDUCATION SYSTEM MODEL
NOTE        REVISION 11/26/86
NOTE
NOTE
NOTE         RESOURCE SECTOR
NOTE
L       RESAV.K=RESAV.J+(DT)(RESAL.JK-RESSPT.JK)
N       RESAV=500.00
NOTE          INITIAL RESOURCES
NOTE
R       RESAL.KL=FUNDS.K/T
NOTE          ALLOCATIONS DEPEND UPON FUNDINGS
NOTE             WHICH DEPENDS UPON STUDENT POPULATION
NOTE
R       RESSPT.KL=(ACBUDJ.K+DISS.K)*0.5/T
NOTE          EXPENDITURES DEPEND UPON ACCUMULATED BUDJETS
NOTE
NOTE
NOTE            REMEMBER T= TOTAL TIME OR 36 MONTHS
C       T=48
NOTE
NOTE            PRODUCTION BUDGET
NOTE
A       PROD.K=RESAV.K*PRODIN
C       PRODIN=0.1
NOTE
NOTE            DEVELOPMENT BUDGET
NOTE
A       DEV.K=RESAV.K*DEVIN
C       DEVIN=0.05
NOTE
NOTE            ORGANIZATION MANAGEMENT BUDGET
NOTE
A       ORGD.K=RESAV.K*ORGDIN
C       ORGDIN=0.05
NOTE
NOTE
NOTE            TOTAL ACCUMULATED BUDJETS
NOTE
A       ACBUDJ.K=PROD.K+DEV.K+ORGD.K
NOTE
NOTE
NOTE           INSTRUCTIONAL DEVELOPMENT SYSTEM MODEL
NOTE
NOTE           DISSEMINATION SECTOR
NOTE
A       DISS.K=ACBUDJ.K+RESAV.K*DISSIN
C       DISSIN=0.2
NOTE
NOTE           TOTAL DISSEMINATION DEPENDS UPON ACCUMULATED BUDJETS
NOTE
NOTE           STUDENT POPULATION LEVEL
NOTE
L       STUPOP.K=STUPOP.J+(DT)(ENROLL.JK-GRDROP.JK)
NOTE
R       ENROLL.KL=DISS.K*ENROFR.K
```

```
NOTE            RATE OF ENROLLMENT DEPENDS UPON EXPENDITURES
NOTE
NOTE
A       ENROFR.K=TABLE(TENROL,FROTOP.K,0,1,0.1)
NOTE
NOTE            ENROLLMENT FRACTION BASED UPON TABULAR DATA
NOTE
T       TENROL=0.10/0.10/0.09/0.09/0.08/0.07/0.05/0.05/0.04/0.03/0.02
NOTE
NOTE            ENROLLMENT TABLE
NOTE
A       FROTOP.K=STUPOP.K/TOTPOP
NOTE
NOTE            FRACTION OF TOTAL POPULATION WHO ARE STUDENTS
NOTE
C       TOTPOP=500
NOTE            TOTAL INITIAL POPULATION
NOTE
NOTE
R       GRDROP.KL=STUPOP.K/T
NOTE            RATE OF MATRICULATION
NOTE
N       STUPOP=25.00
NOTE            INITIAL STUDENT POPULATION

NOTE            FUNDING
NOTE
NOTE             FUNDING IS DEPENDENT ON STUDENT POPULATION    +STUPOP=+FUND

A       FUNDS.K=STUPOP.K*.05*DOLPER
C       DOLPER=10
NOTE             DOLLARS PER STUDENT
NOTE             FUNDS THEN FEED BACK INTO RESOURCE ALLOCATION RATE
NOTE
NOTE
NOTE

PLOT    RESAV=R,STUPOP=S
SPEC    DT=1/PLTPER=1/LENGTH=48
PLOT    ENROLL=E,GRDROP=M
PLOT    RESAL=L,RESSPT=R
PLOT    PROD=X,DEV=D,ORGD=O,DISS=S
RUN
```

The Effect of the Number and Nature of Features and of General Ability on the Simultaneous and Successive Processing of Maps

Sandra Sutherland and William Winn
College of Education
University of Washington

Running head: The Effect of the Number and Nature of Features

ABSTRACT

Twenty-nine graduate students studied a series of four maps. Elements in the maps were shown either as symbols or squares. Each element was labeled and numbered from left to right, top to bottom. Subjects were required to either list the elements in sequence or draw the overall pattern. Findings were significant for number of elements in the map, task, and task by map interaction. A correlation was also found between one of the maps and the pre-test. Conclusions were drawn as to processing strategies utilized by participants and implications for design of educational materials.

INTRODUCTION

Graphics in text add a unique dimension to communication in educational materials. They afford a bridge between pictures and text which the learner may use for more complete understanding than through either text or pictures alone. They can be constructed with varying degrees of verbal embellishment, allowing application throughout a broad spectrum of student abilities.

Graphics include a spatial dimension which is unavailable in text-only materials. On the other hand, materials which are strictly pictorial do not allow the learner to integrate language along with the image. Not only are the graphic images themselves subject to variation, but the layout into which they are assembled can also take many forms. Fleming and Levie (1978) refer to a kind of syntax unique to graphics. Word and image used together reinforce each other, appealing to both verbal and visual memories.

There is some evidence that varying the amount and type of detail in elements of a graphic layout may effect the memorability of the layout itself. Winn (1986a) studied students' abilities to list (in order) or draw a pattern of electronic components in circuit diagrams with differing amounts of detail. He found that more detail appeared to aid memory in the list task, but detracted from memory for spatial relationships (drawing). On the other hand, less detail aided memory for drawing elements in relation to each other, while it interfered with ability to remember a list of components.

Amlund, Gaffney and Kulhavy (1985) found that map-featured information was better recalled than nonfeatured information by all groups in two experiments they conducted to investigate validity of the conjoint retention hypothesis (that independent coding of spatial and semantic information facilitates recall). That study suggested that familiar symbols are superior to unfamiliar symbols.

Graphics can be processed two different ways. First, they can be interpreted sequentially. Although the whole layout may be visually available, viewing the information may dictate processing in a sequential manner, either due to the logic within the information being presented (start to finish) or to the task required afterward. Wholistic interpretation is a second possibility. In order to grasp a systemic process where there is no beginning and no end (as in a diagram showing biological cycles), mentally assembling parts together to form an integrated whole is an absolute necessity for comprehension of the message. Or wholistic integration may be required by any of a number of other tasks.

Simultaneous and successive processing have emerged within the past decade as parts of investigation into relationships among various aspects of learning, including reading, composition, graphics and education of the handicapped. Simultaneous processing is defined by Das (1979) as "the synthesis of separate elements into groups, these groups often taking on spatial overtones". Successive processing, on the other hand, refers to "processing information in a serial order". Das makes the distinction that simultaneous processing deals with objects that are "at once surveyable" while successive processing deals with those "not totally surveyable".

Based in neurology, simultaneous and successive processing are not located in specific brain centers, but are the result of the interaction of higher level cortical areas. A large portion of research (Das, 1978, 1979, Kirby & Das, 1977, Luria, 1966, 1973) has involved establishing the validity of the two constructs (simultaneous and successive processing), by the administration of series of tests and factor analytic techniques. The tests included Raven's Progressive Coloured Matrices, Figure Copying and Memory for Designs (simultaneous) and Digit Span, Visual Short-term Memory and Serial or Free Recall (successive). Other researchers have been studying factors that correlate with successive and simultaneous ability as measured by these tests (McRae, 1986, Wachs and Harris, 1986). Still others (Amlund, Gaffney and Kulhavy, 1985, Winn, 1986) have designed special materials for investigating simultaneous and successive processing by performance of designated tasks.

Research on Simultaneous and Successive Processing

Simultaneous and successive processing were explored in the work of Russian neurologist A.R. Luria. Luria (1966, 1973) found difficulty in simultaneous processing among patients with lesions in the left parieto-occipital lobe. He noted that these patients could not integrate visual or tactile stimulation into simultaneous, spatially organized groups. Successive processes appeared intact. Patients with damage in the fronto-temporal lobe, on the other hand, were not able to integrate motor and acoustic stimuli into successive, serially organized groups.

Das investigated simultaneous and successive processing (Das, Kirby, & Jarman, 1978, Das, Che & Williams, 1979, and Das, 1983) on the basis of Luria's work, including educational applications with the handicapped. He suggests that it is most appropriate to conduct instruction with students through that processing ability which is more intact and to teach strategies which can then be used by the student in processing academic information. Das feels that learning-disabled students did not succeed in processing materials as well as "normals" (Das, Che & Williams, 1979) due to a lack of ability to choose the appropriate strategy. In another study (Kirby & Das, 1977) it was found that those students who were able to process material better, both simultaneously and successively, were also able to read better. Again, Das attributed this to having a choice of strategies available. In both studies the students were comparable in regard to I.Q.

McRae (1986) investigated the relationship between simultaneous/ successive processing and word recognition/comprehension in reading of primary grade children based on Das's work. McRae found indications of a relationship between simultaneous processing and reading comprehension.

Wachs and Harris (1986) looked at simultaneous and successive processing in relation to math and composition abilities, also based on Das's work. Significant correlations were found between simultaneous processing and SAT math scores. Significant correlations were also found between successive processing and grades in an introductory English composition course, supporting the Das-Luria model. Wachs and Harris believe that simultaneous/successive processing contributes to academic performance in college students.

Application in Research on Graphics

Winn (1980, 1981, 1982, 1983) has investigated various aspects of graphic communication, finding that the manner of visual presentation makes a difference in learning and retention. Subsequently, he took the Das-Luria model farther than most researchers in that he utilized graphic instructional materials in his studies rather than the usual test materials used in work by Das and other researchers. Winn has used simultaneous/successive processing to interpret some of his data, and to formulate hypotheses tested in later studies (Winn, 1986a, 1986b).

The study reported here investigated the interactions of three factors indicated in Winn's previous studies which may be involved with memory for pattern or sequence in visual materials, specifically, the interactions among 1) arbitrariness of representation, 2) task, and 3) ability of students. The earlier study found that representing electronic components as symbols, as opposed to squares, interfered with student ability to recall the pattern the elements formed. In contrast to Winn's study with electronic circuit diagrams, symbols selected for this study were realistic pictures. Like the circuit diagram study, symbols were laid out on a grid structure (previously as circuit diagrams, now as maps), and squares were used for the alternate symbol system. Treatment and task were both similar to the previous study. It was expected that treatment (study of pictures or squares) would interact with task (draw or list elements). It was also expected that performance on both tasks would decrease with an increase in the number of elements per map, due to short-term memory limitations (approximately seven elements; Miller, 1956). The sequence task, requiring successive processing, doesn't allow use of the "chunking" strategy (remembering a cluster of elements as one group) which is available in simultaneous processing (Das, et al., 1979). Basic ability of the subjects, measured by Raven, was also expected to play an important role in memory for sequence and pattern as difficulty increased.

METHOD

Subjects

Subjects participating in the experiment were twenty-nine graduate students in Education. They were randomly assigned to each of four groups.

Design

The design of the study was a two by two by four factorial, with task (list vs. draw) and treatment (pictures vs. squares) as between subjects factors, and map (8, 12, 16, 20 elements) as a within subjects factor. The dependent variable was the number of elements either 1) listed in the correct order (successive task) or 2) drawn correctly relative to other elements (simultaneous task).

Materials

Two versions of four maps were prepared, one version with small pictures of locations in a city, and another with squares in these same positions. Each corresponding element (realistic picture or square) was identified with the same word ("store", "factory", "bridge", etc.). Each symbol and accompanying word was numbered, left to right and by rows, from top to bottom. Four levels of each map included eight, twelve, sixteen and twenty elements each.

Packages received by subjects comprised a cover sheet with instructions, followed by four maps separated by blank sheets of paper. After studying each map, the required task (list or draw) was completed on the next blank sheet of paper. Maps were in order of increasing complexity.

Procedure

Sets D and E of Raven's Progressive Matrices were administered to all subjects in order to assess their general ability.

A week later, at the treatment session, materials were randomly distributed. Subjects who received the sequence packets were tested in a different room than those who received the pattern packets. In an earlier study (Winn, 1986a), a ceiling effect was found for the sequence group when the test period lasted three minutes. In this study, the time limit for the sequence task was lowered to avoid this, while time for the pattern task was not changed, necessitating separate testing areas.

=======================
TABLE 1 ABOUT HERE
=======================

The sequence group had one and a half minutes to study the maps, and one and a half minutes to list the elements in order. The pattern group had three minutes to study the maps and another three minutes to draw the pattern from memory. Instructions were for subjects to depict location of each element, in the form of a square, regardless of whether they had studied pictures or squares. They were asked not to label or number their drawings.

Maps were studied, and drawn or listed, in order of increasing complexity, beginning with the eight element map and ending with the twenty element map.

Scoring

In scoring the sequence task, one point was given for each element listed in the correct order. If an element was missing, but others were in the correct order, credit was given for all parts sequentially listed. Scoring for the pattern task was more difficult. Because of the variability in accuracy with which the subject drew the diagrams, scores were based on the relative rather than absolute placement of elements. Each map was scored by three people. Final scores were an average of the three evaluations.

Raw scores were converted to percentages because the number of features on the four maps were not equal. Two by two by four repeated measures analysis of variance was performed. Task and treatment were between subjects factors, map was a within subjects factor. In the event interaction between map and either task or treatment were significant, separate two by two analyses of variance were planned. Interactions between map scores and results of Raven's matrices were analyzed using multiple regression.

RESULTS

Means and standard deviations for each of the four maps are shown in Table 2. There were no significant findings for treatment or task, nor for the task by treatment interaction. However, significant differences were found for map, F(3, 75)=20.5 p<.001 and for the task by map interaction F(3, 75)= 15.7, p<.001.

========================
TABLE 2 ABOUT HERE
========================

Scores generally declined as the number of elements increased.

=======================
TABLE 3 ABOUT HERE
=======================

Percentages of correct scores declined steadily for the sequence task. They initially declined in the pattern task, but then they levelled off, and rose again.

Two-way factorial analysis of variance for each map separately revealed some significant differences for the eight element map. Subjects in the sequence task group scored higher than subjects in the pattern task group. For task, F(1, 25)= 10.3, p<.01. Scores are shown in Table 4.

TABLE 4 ABOUT HERE

For the task by treatment interaction, F(1, 25)=3.99, p=.06, scores are shown in Table 5. Subjects who drew patterns after studying pictures performed considerably better than those who drew patterns after studying squares. Viewing pictures or squares made no significant difference in performance when listing the elements. Analysis of simple main effects, showed the two means for the pattern task to be significantly different, F(1,12)=6.40, p<.05.

TABLE 5 ABOUT HERE

No significant main effects were found for the 12 or 16 element maps. However, on the twenty element map, task was significant, F(1, 25)=20.78, p<.001. Scores for the pattern task were significantly higher than the scores for the sequence task, the opposite of findings on the eight element map.

TABLE 6 ABOUT HERE

Multiple regression revealed a significant interaction, F(7, 21)= 2.4, p=.058, between the pattern and sequence tasks with Raven scores as a predictor for the twenty element map. The interaction was ordinal, and indicated that Raven scores could predict performance on the sequence task but not on the pattern task.

TABLES 7 & 8 ABOUT HERE

DISCUSSION

Subjects who were part of the sequence group were unable to retain more than approximately seven items, as predicted by research (Miller, 1956). Although percentages declined over maps, this served as more of a reflection of the increase in the number of elements per map than of an inability to succeed on the part of the participants. In fact, mean scores per map were, in order, 7.54, 8.70, 8.82 and 9.27, all above the standard seven.

Scores on the pattern task did not follow the same profile. While percentages initially declined, they flattened out and then rose again as the number of elements increased. Participants may have used a chunking strategy, combining several elements into one unit of memory, to extend the total number of elements retained. It appeared that the twenty element map either allowed the greatest opportunity for chunking or forced the participants to resort to it. The percentage remembered was nearly as high on the twenty element map as it was on the map with eight elements. Mean scores per map were 6.21, 7.50, 10.14 and 15.43. The eight element map was easier for participants remembering the elements in sequence. In contrast, chunking strategies made the twenty element map easier to recall for those trying to remember elements they surveyed simultaneously. An examination of the maps with 12 and 16 elements revealed patterns that were not as easy to cluster.

Dependency of performance on the number of elements in a map also extended to the differential effects of task and treatment. The interaction of task with treatment, involving only the eight element map, was contrary to what was expected on the basis of Winn's (1986) circuit diagram studies. It had been expected that adding detail to the elements would make it easier for students to perform on the sequence task but would not aid in the pattern task. In fact, students who studied pictures scored higher on the pattern task than those who studied squares. This supports Amlund, Gaffney and Kulhavy (1985) who found greater memorability for maps with pictures than other symbols. In contrast to Winn's electronic diagram study, symbols used in this study were familiar (house, church, etc.), while symbols in the earlier study were abstract and unfamiliar. Kulhavy, Schwartz and Shaha (1983) have reflected on the possibility of unfamiliar symbols actually interfering with learning.

Another example of how the number of elements affected performance is found in the relationship between task and student ability. When the task became most difficult (the twenty element map) an aptitude treatment interaction showed that low ability students performing the sequence task had the greatest difficulty. Performance on the pattern task was not affected by ability. There was no difference on either task for high ability students. This indicates that while ability may be necessary for good performance on the sequence task, use of a chunking strategy compensated for low ability on the pattern task.

This study has shown that performance on simultaneous and successive processing of maps is determined more by the number of elements per map than by the amount of detail in its elements. The value of graphics to communicate information by spatial layout is supported by the contribution of a chunking strategy during simultaneous processing which is not available in the sequence task requiring successive processing.

Interaction of task and treatment, in contrast with the earlier circuit diagram study, suggests a need to consider familiarity of elements along with task, amount of detail and student ability. Also suggested is a need for further studies in which familiarity as well as complexity of details in elements in graphics is varied.

Indications for education are that when more than seven elements are presented in maps, difficulties may result when students are required to perform a successive task. On the other hand, when the task calls for simultaneous processing, access to a chunking strategy will enable students to compensate for the numerous elements. This supports Das (1978, 1979, Kirby & Das, 1977) when he observes that teaching chunking strategies to students may increase their abilities to remember elements in visual materials.

Amlund, J.T., Gaffney, J., & Kulhavy, R.W. (1985). Map feature content and text recall of good and poor readers. Journal of Reading Behavior, 17 (4), 317-330.

Das, J.P., (1983). Memory for spatial and temporal order in deaf children. American Annals of the Deaf, December, 894-899.

Das, J.P., Kirby, J.R., & Jarman, R.F. (1979). Simultaneous and successive cognitive processes. New York: Academic Press.

Das, J.P., Che, K.L., & Williams, N.H. (1978). The relationship between learning disability and simultaneous-successive processing. Journal of Learning Disabilities, 11 (10), 16-23.

Fleming, M.L. & Levie, W.H. (1984). Instructional message design: principles from the behavioral sciences. Englewood Cliffs, NJ: Educational Technology Publications.

Jaben, T.H. (1986) Impact of creativity instruction on learning disabled students' divergent thinking. Journal of Learning Disabilities, 19 (6), 342-343.

Kirby, J.R. & Das, J.P. (1977). Reading achievement, I.Q., and simultaneous-successive processing. Journal of Educational Psychology, 69 (5), 564-570.

Kulhavy, R.W., Schwartz, N.H., & Shaha, S.H. (1983). Spatial representation of maps. American Journal of Psychology, 96, 337-351.

Lovitt, T., Rudsit, J., Jenkins, J., Pious, C., & Benedetti, D. (1985). two methods of adapting science materials for learning disabled and regular seventh graders. Learning Disability Quarterly, 8, 275-285.

Lovitt, T., Rudsit, J., Jenkins, J., Pious, C., & Benedetti, D. (1986). Adapting science materials for regular and learning disabled seventh graders. Remedial and Special Education, 7 (1), 31-39.

Luria, A.R. (1966). The human brain and psychological processes. New York: Harper & Row.

Luria, A.R. (1973). The working brain. London: Academic Press.

McRae, S.G. (1986). Sequential-simultaneous processing and reading skills in primary grade children. Journal of Learning Disabilities, 19 (8), 509-511.

Miller, G.A. (1956). The magical number seven, plus or minus two: some limits in our capacity for processing information. Psychological Review, 63, 81-97.

Wachs, M.C. & Harris, M. (1986). Simultaneous and successive processing in university students: contribution to academic performance. Journal of Psychoeducational Assessment, 4, 103-112.

Winn, W. (1980). The effect of block-word diagrams on the structuring of science concepts as a function of general ability. Journal of Research in Science Teaching, 17 (3), 201-211.

Winn, W. (1981). Effect of attribute highlighting and spatial organization on identification and classification. Journal of Research in Science Teaching, 18 (1), 23-32.

Winn, W. (1982). The role of diagrammatic representation in learning sequences, identification and classification as a function of verbal and spatial ability. Journal of Research in Science Teaching, 19 (1), 79-89.

Winn, W. (1983). Perceptual strategies used with flow diagrams having normal and unanticipated formats. Perceptual and Motor Skills, 57, 751-762.

Winn, W. (1986, April). Simultaneous and successive processing of circuit diagrams having different amounts of detail. Paper presented at annual meeting, American Educational Research Association, San Francisco.

Winn, W. (1986). Knowledge of task, ability and strategy in the processing of letter patterns. Perceptual and Motor Skills, 63, p. 726.

Winn, W.D., & Holliday, W.G. (1982). Design principles for diagrams and charts. In D. Jonassen (Ed.) The technology of text(Vol. 1, pp.277-299). Englewood Cliffs, NJ: Educational Technology Publications.

Table 1 Summary of Maps and Tasks

	Group 1	Group 2	Group 3	Group 4
TASK	sequence	pattern	sequence	pattern
MAP	realistic w/labels	realistic w/labels	squares w/labels	squares w/labels
NO. OF ELEM.	8, 12, 16, 20	8, 12, 16, 20	8, 12 16, 20	8, 12 16, 20

Table 2

Mean Percentages of Correct Items by Map.

(Standard Deviations in Parentheses)

	Squares		Pictures	
No. of elements	Sequence	Pattern	Sequence	Pattern
8	96.43	69.94	92.19	85.71
	(9.45)	(14.17)	(11.45)	(18.30)
12	67.86	54.76	77.08	70.24
	(31.71)	(15.11)	(17.68)	(12.60)
16	50.89	63.39	59.38	63.39
	(16.31)	(17.83)	(14.17)	(15.91)
20	46.43	69.29	46.25	85.00
	(25.61)	(10.58)	(20.13)	(12.58)

TABLE 3 Scores per map

MAP	8	12	16	20	
sequence	94	73	55	46	%
pattern	78	63	63	77	%

TABLE 4

EIGHT ELEMENTS

TASK

		draw	list	
TREATMENT	pictures	85.7	92.2	88.95
	squares	69.6	96.4	83.0
		77.65	94.3	averages

TABLE 5

INTERACTION

TASK

		pattern	sequence	
TREATMENT	pictures	76.1	68.7	72.2
	squares	64.3	65.4	64.8
		70.2	67.2	averages

TABLE 6

TWENTY ELEMENTS

TASK

		pattern	sequence	
TREATMENT	pictures	85.0	46.2	65.6
	squares	69.2	46.4	57.8
		77.1	46.3	average

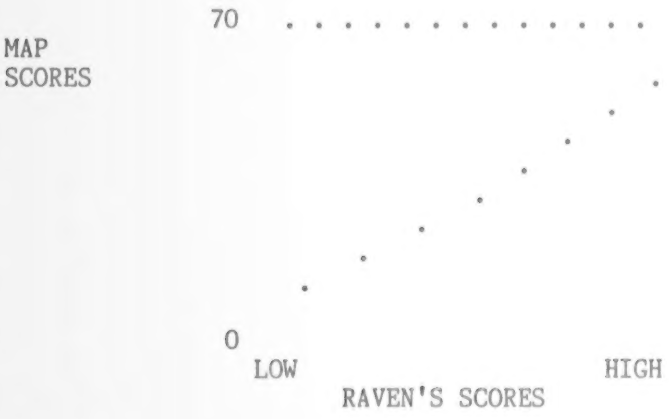
Table 7

Statistics for Interaction of Ability with Task

	Unstandardized Regression Coefficient	Y Intercept
Sequence	4.99	-44.12
Pattern	.20	73.60
Maximum and minimum slope of Ya-Yb with 95% confidence interval	7.06 and -2.51	

R squared	Change in R squared	MS residual	F	p
.602	.089	256.93	5.65	<.05

TABLE 8 RAVEN'S SCORES GENERALLY CORRELATED WITH MAP SCORES



Schema Theory: A Basis for Domain Integration Design

Katsuaki Suzuki

Department of Educational Research
Florida State University

Address: Rm. 307 Stone Bldg
Florida State University
Tallahassee, FL 32306

Paper prepared for the symposium, Application of Schema Theory to Instructional Design, at the Annual Meeting of the Association for Educational Communications and Technology, Atlanta, GA (March, 1987).

Schema Theory: A Basis for Domain Integration Design

Katsuaki Suzuki
Florida State University

In recent years, human cognition and knowledge structure have been extensively investigated in terms of schemata (e.g., Anderson, 1984a; Rumelhart, 1980). Schemata are claimed to be the basic units of human knowledge. A schema is defined as "an organized body of knowledge, conceived theoretically as a set of interconnected propositions centering around a general concept, and linked peripherally with other concepts (Gagné, 1986, p. 12)". It has been demonstrated by schema research (e.g., Pichert & Anderson, 1977) that the schemata existing in a person's knowledge structure influence the way newly-coming information is interpreted and acquired.

Schema theory explains internal conditions of learning, which can be applied in instructional design in various ways. In this paper, schematic interpretation of human cognition is first related to human capabilities, for which instruction is designed. Then, instructional implication of the schema theory will be discussed for integration of learning outcome domains. Finally, procedures for the design of instruction will be suggested emphasizing integration of various outcome domains.

A Schema and Associated Domains of Learning Outcomes

In order to relate schematic representation of human knowledge and instructional design, it is helpful to describe a schema in terms of the domains of learning outcomes; intellectual skills, verbal information, cognitive stragegies, attitudes, and motor skills (Gagné, 1985). The domain of learning outcomes must be identified for each objective in instruction because it informs an instructional designer of a distinctive set of effective instructional strategies. In this sense, analyzing a schema into the domains of learning outcomes may enable us to identify what exactly a schema is, in relation to how we can facilitate the learning of it.

A schema is said to be formed around a general concept, which belongs to the domain of intellectual skills. Concepts are intellectual skills in that they provide rules for classifying incoming information (Gagné, 1985). Such a function is known as "ideational scaffolding (Anderson, 1984a)", for which the "slot" structure of a schema is utilized. For example, if one has a schema for "monument", he or she can tell if a given description is about a monument or not by applying such classification rules as "Is it a structure (such as a building or sculpture)?" and "Is it for a memorial?" If the slot for the memorial cannot be filled out by a person or event from the description, then the example may not be considered to be a monument, but a mere building. Thus, by using the monument schema, and other related schemata, one can classify instances of monuments and other related concepts (e.g., ordinary buildings, memorial holidays).

A schema also contains individual examples of the schema, which are in the verbal information domain. A schema has accumulated instances of the general concept. These instances are known as "instantiations" of the schema (Anderson, 1984a). For example, the "monument schema" may contain the facts about the Washington Monument as an instantiation; about its location, history, configuration, and to whom it is dedicated. Other related information may be associated with the monument schema, including episodic facts (e.g., when the learner saw the monument, with whom, the weather of the day, etc.), and historical notes of the dedicator.

Another type of cognitive capability is associated with a schema, which can be classified in the domain of cognitive strategies. Cognitive strategies control internal information-processing, which are also known as "metacognition", or more specifically, "self-regulatory mechanisms used by an active learner" (Armbruster & Brown, 1984, p. 274). Each schema not only has intellectual skills and verbal information, but also is equipped with cognitive strategies. Rumelhart (1980) has stated: "Embedded in these packets of knowledge [i.e. schemata] is, in addition to the knowledge itself, information about how this knowledge is to be used" (p. 34). Although cognitive strategies for general uses may be located elsewhere, the strategies employed mainly for the learning about monuments (i.e. domain specific strategies) is best placed within the monument schema.

It is natural to assume that attitudes are related to schemata, toward which the attitudes are formed. Schemata are formed around general concepts of objects, situations, and events. Attitudes are "internal states that influence the individual's choice of personal action [toward some category of objects, persons, or events]" (Gagné, 1985, p. 219). Thus, each schema is likely to be accompanied with an affective proposition about that schema, which influences personal choices associated with the schema. If a person is not interested in history in general, he or she may not choose to visit or study about monuments, for example. A student of history and of architecture may develop very different schemata of monuments because of their different interests. Although knowing something is different from liking something, attitudes seem to be a part of schemata.

In short, both cognitive and affective domains of learning outcomes seem to be parts of each schema. That is, a schema may be related to capabilities of intellectual skills, verbal information, cognitive strategies, and attitudes. Located within an individual schema, these various capabilities are related to each other. Acquiring one capability is likely to have an effect on other types of capabilities within the same schema.

From Schema Theory To Domain Integration Design

Gagné's (1985) distinction between the domains of verbal information and intellectual skills can be made parallel to the types of learning processes proposed by schema theorists. When verbal information is learned, no change in schema structure is necessary; in-coming information will be assimilated to an existing schema using existing "slots" of the schema. If you learn about a monument in Japan, for example, you will use the same fact categories that are used to learn about the Washington Monument: its location, history, configuration, and to whom it is dedicated. In other words, the existing "monument schema" will be activated (Bransford, 1984) to assimilate another instantiation of the schema. Rumelhart and Norman (1978) have called this process "accretion".

In contrast, when a child learns what a monument is, he or she is acquiring the slots in "monument schema". The Washington Monument may be used to exemplify the classification rules of the monument concept. However, it is not the main objective of the learning to be able to state the facts about the Washington Monument. Instead, the objective is to organize the "monument schema" so that new information can be judged as to wether it is about another monument or not. This process involves either tuning up the existing "monument schema", which is not yet well-articulated, or creating a new "monument schema" by using existing similar schemata.

Schema theory appears to be compatible with the notion of intellectual skills as building blocks for the design of instruction (Gagné & Briggs, 1979). Rumelhart and Norman (1978) have distinguished these processes of the evolution of existing schemata (tuning) and the creation of new ones (restructuring) as different modes of learning from the accretion process. These authors have also argued that the tuning and restructuring processes are not as frequent as accretion, but more significant. Without a change in schema structure, new concepts cannot be formed. On the other hand, when an intellectual skill is learned, the basic structure of the schema surrounding that skill is formulated. Because the memory structure is built by interrelated schemata, instruction may best be planned for finishing up such a structure when a lesson, or section is completed.

Even when a target objective is not an intellectual skill, it may be advantageous to relate the target objective to an intellectual skill objective. That is, try to identify and help formulating a more structured schema surrounding that target objective by adding related intellectual skill objectives. For example, the terminal objective for a math lesson may be to memorize conversion formulas among metric units of length, area, and volume measurements. The learners could try to memorize all individual formulas (e.g., $1\ m^2 = 10000\ cm^2$). However, after studying the formulas for length, the learners can be introduced to a rule that relates length with area and volume. Once this rule is acquired, the learner does not need to remember all of the formulas, but only the formulas for length and how to apply them for area and volume (e.g., $1\ m = 100\ cm$; thus, $1\ m^2 = 1\ m \times 1\ m = 100\ cm \times 100\ cm = 100 \times 100\ cm^2 = 10000\ cm^2$).

A more structured schema, which includes more intellectual skills, will enable the learner to transfer the structure to formulate another schema when needed. The more structured a schema becomes, the more useful it is for further learning. Anderson (1984b) has pointed out that school education is likely to reinforce the "weak" views of knowledge by teaching individual facts separately. By using intellectual skills as the building blocks of curriculum, we may also be able to support a strong view of knowledge, with which the learners will try to utilize what they know in a constructive manner.

Another implication from the schema theory is to integrate various domains of learning outcomes, which presumably are associated with the schema of the terminal intellectual skill objective. The basic units of memory structure are schemata, and each of the schemata is more than its core intellectual skill. Therefore, other related capabilities can also be learned to make the new learning more complete.

For the sake of argument, such capabilities may be called as "accompanying objectives". Instruction would be designed for an intellectual skill terminal objective and its accompanying objectives. The accompanying objectives are NOT subordinate to the terminal objective in the sense of "essential prerequisites", the absence of which disable the learning of the terminal objective. Although these related capabilities may support the learning of the terminal objective (i.e., "supportive prerequisites"), the accomplishment of the accompanying objectives are, for themselves, terminal. The teminal intellectual skill objective plus the accompanying objectives may represent more complete schema than the intellectual skill alone.

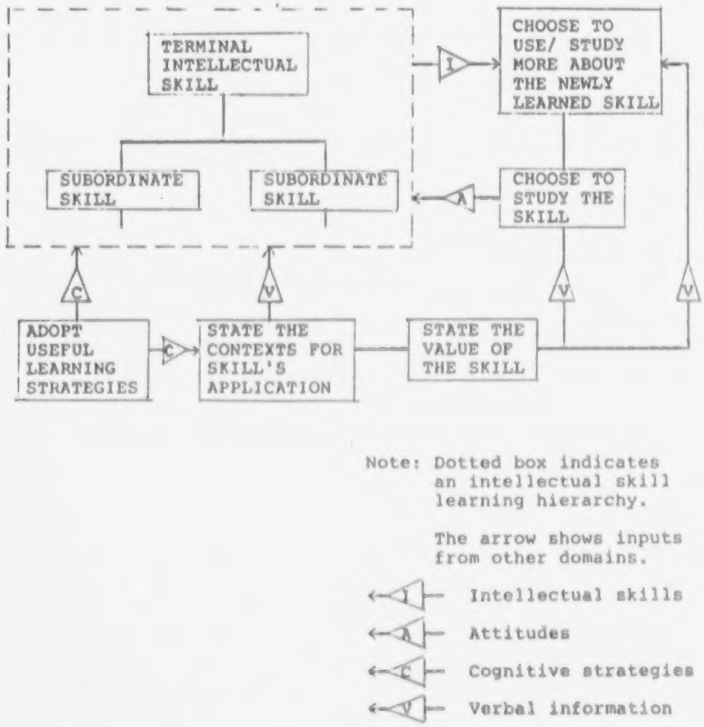
Various types of accompanying objectives have been proposed in the literature in several different terms. White and Mayer (1980) proposed a classification system of verbal information related to the learning of an intellectual skill into productive and unproductive types. Accompanying cognitive strategies have been investigated by the learning strategy researchers. Derry and Murphy (1986) have proposed that the learning of cognitive strategies be embodied into the cognitive skill and knowledge instruction after the initial exposure to the strategies. An intellectual skill and an accompanying attitude are called "twin objectives" by Briggs and Wager (1981), who have suggested the inclusion of an attitude counterpart of the target objective in lesson and unit design. Other related affective outcomes have been integrated in design of cognitive outcome domains by Martin and Briggs (1986) and Keller (1983).

Given a specific lesson objective, one may be able to derive accompanying objectives by seeking a more complete schema. To follow Gagné's approach in constructing learning hierarchies, a question can be asked: "What else can the learner learn in order to enhance the schema related to the target intellectual skill objective, absence of which restricts the utilization of the target skill?" The target objective alone will be sufficient for a learner to demonstrate the skill when and if so asked. However, the accompanying objectives will help in enhancing the surrounding schema, with which the target skill may better be utilized for practical situations, or for related learning tasks. In other words, when this question is asked, not only the end-of-lesson accomplishments, but also long-term effects should be taken into consideration.

In order for the target skill to be utilized, a learner must be able to perform the skill. In addition, there seem to be several other general types of the accompanying capabilities. The learner must:

(1) be able to perform the skill (terminal objective).
(2) know when the skill can be applied (contextual knowledge; verbal information).
(3) be able to use the skill when needed (initiating internal processes; cognitive strategies).
(4) choose to use the skill (positive attitude toward using the skill).

In Figure 1, these terminal and accompanying objectives, and some other supporting objectives are summarized in the form of a generic Instructional Curriculum Map (ICM, Briggs & Wager, 1981). The ICM presents hypothesized interrelationships among the related objectives from various outcome domains. It should be helpful for an instructional designer to visualize how objectives from different domains of learning outcomes may help each other. It may be used to select instructional strategies, as well as to determine the sequence of instruction among the depicted objectives.


TERMINAL INTELLECTUAL SKILL
SUBORDINATE SKILL
SUBORDINATE SKILL
CHOOSE TO USE/ STUDY MORE ABOUT THE NEWLY LEARNED SKILL
I
CHOOSE TO STUDY THE SKILL
A
C
V
V
V
ADOPT USEFUL LEARNING STRATEGIES
C
STATE THE CONTEXTS FOR SKILL'S APPLICATION
STATE THE VALUE OF THE SKILL
I Intellectual skills
A Attitudes
C Cognitive strategies
V Verbal information

Note: Dotted box indicates an intellectual skill learning hierarchy.

The arrow shows inputs from other domains.

Figure 1. Generic ICM Summarizing Accompanying Objectives.

Concluding Remarks

Looking at the schema theory of human cognition, this paper discussed some implications for designing instruction. These implications include the central role of the intellectual skills domain in learning and the advantages of integrating various outcome domains in instructional design. The notion of accompanying objectives was proposed to design an instructional segment for a richer learning outcome, which presumably represents a more complete state of the surrounding schema. Instructional Curriculum Maps are employed as visual representations for integrating various domain of learning outcomes in design effort.

In order to apply the two implications emerged from the schema theory, the procedures for the instructional design will be as follows:

1. Define the lesson objective. If the lesson objective is not an intellectual skill, find a related intellectual skill.
2. Lay out essential subordinate skills, constructing a learning heirarchy.
3. Explore accompanying objectives that help utilizing the teminal skill. The generic ICM (Figure 1) may be helpful at this point.
4. Lay out the accompanying objectives and other supportive objectives, forming an ICM.
5. Determine the instructional strategies for the terminal objective taking other objectives into account.

It is the presenter's hope that a strong view of knowledge (Anderson, 1984b) will be emphasized in as many occasions as possible whenever an instructional segment is systematically designed. To accomplish that end, it seems to be a good course of action to emphasize the domain of intellectual skills and also to take other types of learning outcomes into account. By integrating various outcome domains in instructional design, we can also develop positive attitudes toward learning, knowledge for applying the learned skills, and strategies for learning within the instruction emphasizing the learning of intellectual skills.

References

Anderson, R. C. (1984a). Role of the reader's schema in comprehension, learning, and memory. In R. C. Anderson, J. Osborn, & R. J. Tierney (Eds.), *Learning to read in American schools: Basal readers and content texts*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Anderson, R. C. (1984b). Some reflections on the acquisition of knowledge. *Educational Researcher*, *13*, 5 - 10.

Armbruster, B. B., & Brown, A. L. (1984). Learning from reading: The role of meta-cognition. In R. C. Anderson, J. Osborn, & R. J. Tierney (Eds.), *Learning to read in American schools: Basal readers and content texts*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Bransford, J. D. (1984). Schema activation and schema acquisition: Comments on Richard C. Anderson's remarks. In R. C. Anderson, J. Osborn, & R. J. Tierney (Eds.), *Learning to read in American schools: Basal readers and content texts*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Briggs, L. J., & Wager, W. W. (1981). *Handbook of the procedures for the design of instruction* (2nd Ed.). Englewood Cliffs, NJ: Educational Technology Publications.

Derry, S. J., & Murphy, D. A. (1986). Designing systems that train learning ability: From theory to practice. *Review of Educational Research*, *56*, 1 - 39.

Gagné, R. M. (1985). *The conditions of learning and theory of instruction* (4th Ed.). New York: Holt, Rinehart, and Winston.

Gagné, R. M. (1986). Instructional technology: The research field. *Journal of Instructional Development*, *8*(3), 7 - 14.

Gagné, R. M., & Briggs, L. J. (1979). *Principles of instructional design* (2nd Ed.). New York: Holt, Rinehart, and Winston.

Keller, J. M. (1983). Motivational design of instruction. In, C. M. Reigeluth (Ed.), *Instructional-design theories and models: An overview of their current status*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Martin, B. L., & Briggs, L, J. (1986). *The affective and cognitive domains: Integration for instruction and research*. Englewood Cliffs, NJ: Educational Technology Publications.

Pichert, J. W., & Anderson, R. C. (1977). Taking different perspectives on a story. *Journal of Educational Psychology*, *69*, 309 - 315.

Rumelhart, D. E. (1980). Schemata: The building blocks of cognition. In R. J. Spiro, B. C. Bruce, & W. F. Brewer (Eds.), *Theoretical issues in reading comprehension*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Rumelhart, D. E., & Norman, D. A. (1978). Accretion, tuning, and restructuring: Three modes of learning. In J. W. Cotton, & R. L. Klatzky (Eds.), *Semantic factors in cognition*. Hillsdale, NJ: Lawrence Erlbaum Associates.

White, R. T., & Mayer, R. E. (1980). Understanding intellectual skills. *Instructional Science*, *9*, 101 - 127.

January 25, 1987

The Effects of Program Embedded Learning Strategies, Using an Imagery Cue Strategy and an Attention Directing Strategy, To Improve Learning from Micro Computer Based Instruction (MCBI)

William Taylor
Associate Professor of Education
Ohio State University

James Canelos
Director of Instructional
Development, College of Engineering
Pennsylvania State University

John Belland
Associate Professor of Education
Ohio State University

Frank Dwyer
Professor of Education
Pennsylvania State University

Patti Baker
Ohio State University

Rationale

This study represents the third in a series of studies dealing with micro-computer based instruction (MCBI) done by the author's Ohio State-Penn State Research Group on Instructional Design and Technology. This research group was started by Canelos and Taylor, with a first study in 1979 (1980a, 1980b), and has generated a series of published research studies since that time.

The initial study dealing with MCBI examined the relative effectiveness of a basic Self-Paced MCBI method and an External-Paced method, (1985a, 1985b). While Self-Paced methods are recommended for many learning situations involving MCBI, this first study found that an External-Paced instructional method improved learning by increasing attention and motivation. This effect held constant, favoring External-Paced over Self-Paced, even for the more difficult learning tasks evaluated, specifically complex concept learning and solving a spatial problem.

The External-Paced method, as a basic method, or strategy, for designing MCBI, was recommended from the results of our initial study because of these increased levels of learning caused by increased attention and motivation. However, it should be noted that a more aggressive External-Paced strategy was tried in this study, and was ineffective. External pacing of MCBI can be effective, but such external pacing must allow enough time for reading, and the cognitive processing of new information, (called cognitive processing time in the initial MCBI Study).

The second study on MCBI, further examined the relative effects of Self Paced and External Paced instructional strategies, (1986; 1987), but added additional learning strategies. Our earlier work on imagery learning, strategies, imagery memory, and encoding specificity, (1981, 1982, 1983, 1984) and cognitive psychology (1982), indicated that imagery memory factors can have a significant impact on the overall acquisition, and recall of information. This impact is particularly true for spatial learning tasks. Other researchers have indicated similar results regarding the effects of imagery on memory and recall, for example Paivio (1970) has done extensive work on imagery, and the work by Kosslyn (1975) is quite interesting regarding the reconstruction of visual memory elements. Therefore, we decided to incorporate imagery strategy effects into our basic MCBI Self-Paced and Externally-Paced instructional conditions. A further consideration was the use of an attention directing strategy, having effects similar to an advance organizer. Recall that early work by Ausubel (1968) and Rothkopf (1967) found positive learning effects using strategies that directed the learners attention towards relevant to-be-learned information, either instructional questions, performance objectives, or post-questions. Since MCBI is basically an individual or independent type of learning experience, such attention directing learning strategies should help the learner identify relevant information that should be learned. Some researchers have already indicated that learners may be very poor judges of what should be learned, and in what order, or how to learn information from MCBI instruction, (Carrier, 1984; Reiser, 1984).

The Attention Directing Strategy was designed to direct the learners attention to spatial information that had to be acquired to be able to solve the spatial learning problem. In our first MCBI study, we found that learners were acquiring verbal information, for use on the concept tasks, but missing a significant amount of spatial information. The MCBI program instructed the learner on the names of the parts of the human heart, and the operation of the heart, thru a series of 57 instructional frames, or computer displays, and instructional questions, and optional feedback loops. Since the information to-be-learned was both verbal and visual, both types of information had to be acquired to complete the five post tests. However, in the first study it was apparent that subjects were not acquiring as much visual information as they should when compared to verbal information acquisition. It was hypothesized that subjects concentrated on verbal information, because the MCBI program instructional questions required a verbal response, thus cueing subjects that verbal information was critical. Similarly, in the classroom situation learners acquire information verbally but may ignore visual information, if it is not emphasized and a significant aspect of testing. The Attention Directing Strategy tended to adjust for this effect by forcing attention to visual information. This strategy was program embedded, in the sense that it was built into the MCBI program, not learned by subjects prior to starting the MCBI program. The Attention Directing Strategy consisted of a 5-second time delay after the visual information in the instructional display was generated, but prior to any verbal explanation. So the learner would see, for example the visual of the heart with the chambers labeled, then 5-seconds pass, prior to any additional verbal description. It should be noted here that a typical instructional display in the MCBI program consisted of a visual of the heart and parts, with labeles and arrows, followed by verbal descriptive information, then an instructional question, feedback and an option for a feedback loop, (see figure 3). The 5-second delay caused the learner to concentrate on the visual portion of the instructional display prior to receiving any competing verbal information. The second strategy was an Imagery Cue Strategy. It was hypothesized that this would further enhance visual learning by causing the learner to form mental images of information acquired, by reconstructing the heart and heart parts from memory into imagery form. The Imagery Cue Strategy was a program embedded strategy, and operated in the following way. After every 5 to 7 completed instructional displays the learner was given a display with an outline drawing of the heart, and asked to fill in the heart parts learned so far by forming an image in his mind. The subject was given 15 seconds to form and manipulate this memory image. While this second study was quite complex, involving an additional trained imagery strategy, and the cognitive style of reflectivity-impulsivity in an 80 cell experimental design, the Attention Directing Strategy and Imagery Cue Strategy resulted in significant effects. The Attention Directing Strategy and Imagery Cue Strategy improved learning on both spatial learning tasks; the Spatial Cued Recall Task, and Spatial Problem Task. The Spatial Problem Task score went from (6.55) overall in the first study, to (9.71) in the second, and the Image Cue Strategy combined with the Attention Directing Strategy had a Spatial Problem Task score of (10.24) for External Paced, and (10.41) for Self Paced. However, due to the complexity of the 80 cell experimental design, there were confounding effects so it was difficult to determine the exact effect of these two strategies when learning from MCBI.

The present study was designed to further examine the effects of the Attention Directing Strategy and Imagery Cue Strategy, as program embedded learning strategies. However, the third studies design was developed to eliminate any confounding effects between instructional variables (see figure 2). Additionally, it was hypothesized that that program embedded learning strategies may operate differently contingent upon the basic MCBI program design of Self-Paced versus Externally-Paced. The research hypothesis for the present study are:

1) The Externally-Paced MCBI basic Program design will be generally more effective than the Self-Paced MCBI design.

2) The Imagery Cue Strategy will improve the learning of Spatial information for performance on Spatial Tasks.

3) The Attention Directing Strategy will improve the learning of Spatial information for performance on Spatial Tasks.

4) The combination of an Imagery Cue Strategy and an Attention Directing Strategy will improve the learning

of Spatial information over either Strategy alone.

5) Program Embedded learning Strategies will have different effects upon learning, contingent upon the basic design of the MCBI program of Self-Paced or Externally-Paced.

Experimental Design and Procedures

The experimental design of the present study is a 9 x 5 x 2 repeated measures design. As can be seen in the block design in figure 1, there are 8 MCBI instructional conditions with, 1 control group, making up the between groups variable. There are 5 levels of the within groups variable that constitute a series of increasingly difficult learning tasks. A second between groups variable is the cognitive style variable of Reflectivity and Impulsivity. The cognitive style data was collected using the three parts of the Barratts test (Barratt and Patton, 1983). These three tests from the Barratt will be analyzed separately and presented in another research paper.

MCBI Experimental Condition

Each of the 8 MCBI conditions were designed to teach subjects about the parts and operation of the human heart during systolic and diastolic functioning. The instructional content was an adaption of the original Dwyer stimulus materials, (heart materials). The instructional content in each of the MCBI programs and sequence of content was identical. Each instructional program contained 57 instructional displays which consisted of visual and verbal instruction describing the heart parts and heart functions. Each display of instruction consisted of a visual with a verbal description and arrow, or arrows, pointing out the important information in that display. There were three types of visuals used in the instructional programs (figure 3). Each instructional display consisted of some combination of one of the visuals and a verbal explanation. Each of the micro-computer instructional programs will be described in detail. The graphics and text were authored using Apple Super PILOT. Verbal instruction was presented in each program, at a normal reading speed, (300 words/min.) although 4 programs are externally paced at the point of instruction and elaborate feedback.

1) Self Paced Instructional Program

The SP instructional program is self-paced at the point of instruction and feedback. Each of the 57 instructional displays start with the heart drawing, then part or phase names appear, then an arrow, or arrows, followed by the instructional text. After each completed instructional display is generated, the learner has as much time as desired to study the instructional display. To move on, the learner presses the return key to receive an instructional question. The instructional display is removed prior to the presentation of each of the 57 questions. The learner responds to the instructional questions by typing in the correct response. The program accepts not only the standard spelling for correct answers but plausible misspellings as well. If the correct response is entered, correct feedback is given in the form of simple feedback (i.e., right, correct). If an incorrect answer is typed in, simple feedback is given that the response is incorrect. The student is then given the option of receiving elaborate feedback, which is the repeat of the instructional display. However, this feedback is completely optional; he or she can move to the next instructional display without feedback. Both the instructional display and the elaborate feedback aspect of the instructional program were completely self-paced.

2) Self-Paced; Imagery Cue Strategy plus Attention Directing Strategy

Instructional condition 2 was identical to condition 1, but with the addition of 2 program embedded strategies. Condition 2 had a Self-Paced MCBI program as the basic instructional design, combined with the program embedded Imagery Cue Strategy and Attention Directing Strategy. The Imagery Cue Strategy was a special screen display designed to promote the formation of mental imagery of parts of the heart. After every 5 to 7 instructional displays, in the series of 57 instructional displays, an Imagery Cue display was given. This screen display was an outline of the heart, without parts or labeles, and a verbal direction to form a mental image of the parts of the heart seen so far and their location and labeles. This screen display stayed up for 15 seconds, then the instructional program continued. The Attention Directing Strategy was designed to help the learner attend to the visual information in each instructional display, prior to studying verbal descriptions presented. To accomplish this the Attention Directing Strategy, was a 5 second time delay between the presentation of the heart visual and labeles, and the verbal descriptive information. During this 5 second delay, the learner could not move ahead, or get additional information. Each of the 57 instructional displays had this 5 second delay between the visual and verbal descriptive information with the Attention Directing Strategy.

3) Self-Paced; Imagery Cue Strategy

Instructional condition 3, was identical to condition 1, but included the Imagery Cue Strategy. Of course, this was identical to the Imagery Cue Strategy from condition 2. As with condition 2, the imagery Cue Strategy was given every 5 to 7 instructional displays, in a special screen display, that lasted for 15 seconds.

4) Self-Paced; Attention Directing Strategy

Instructional condition 4, was identical to condition 1, but included the Attention Directing Strategy. This was the same Attention Directing Strategy from condition 2. The Attention Directing Strategy was a 5 second delay between the generation on the display screen of heart visual information, and verbal descriptive information.

5) Externally-Paced Instructional Program

The EP Instructional Program is externally paced at the point of instruction and elaborate feedback. The 57 instructional displays are identical to the SP instructional condition; containing the same content, in the same order, with each display generated in the same way, and at the same rate. However, the external pacing begins after the instructional display is completed. After each instructional display is completed, the program times the student's interaction with the completed display at a pace of: (a) 1 second per each line of verbal instruction, plus 1 second; so for 5 lines, 6 seconds for reading are given; (b) 7 seconds for cognitive processing are then given, after 1 second per line, plus 1 second, time has elapsed; (c) after reading time and cognitive processing time has elapsed, the instructional display is removed from the terminal screen. To move ahead, the learner presses the return key to receive the instructional question. The learner has as much time as required to respond. If the correct answer is entered, simple feedback is given and the student moves to the next instructional display. If the incorrect answer is typed in, simple feedback is given that indicates an incorrect answer. As in the SP condition, the learner is given the option of receiving elaborate feedback, which is the repeat of the instructional display containing the required answer. The elaborate feedback is optional; the learner can move to the next instructional display or take feedback. Feedback is a repeat of the instructional display and is timed the same way, not allowing self-paced elaborate feedback. Therefore, in the EP instructional program, both instruction and elaborate feedback are externally paced.

6) Externally Paced; Imagery Cue Strategy plus Attention Directing Strategy

Instructional condition 6 was identical to instructional condition 5, but with the addition of the two program embedded strategies of an Imagery Cue Strategy, and an Attention Directing Strategy. The instructional content and content sequence were identical, and the external pace system was identical to condition 5. The combined Imagery Cue Strategy and Attention Directing Strategy were presented in a program embedded format, in the same way they were presented in condition 2. The Imagery Cue Strategy was a special screen display, every 5-7 instructional displays, prompting the learner to form a mental image of the heart parts learned. The Attention Directing Strategy was the 5 second delay, occurring in each instructional display, between the spatial information, and verbal descriptive information.

7) Externally Paced; Imagery Cue Strategy

Instructional condition 7 was identical to instructional condition 5, in terms of content and content sequence and EP instructional design, but with the addition of the Imagery Cue Strategy. The Imagery Cue Strategy was a program embedded strategy and was presented in the same way in condition 7 as the other applications of the Imagery Cue Strategy previously described.

8) Externally Paced; Attention Directing Strategy

Instructional condition 8 was identical to instructional condition 5, in terms of content and content sequence and EP design, but with the addition of the Attention Directing Strategy. The Attention Directing Strategy was a program embedded strategy and was presented in the same way in condition 8 as the other applications of the Attention Directing Strategy previously described.

9) Control

To determine the base rate of the subject's pre-instructional program knowledge of heart physiology, a control group was randomly formed from the pool of 180 subjects participating in the study. The control group took the five tests, but received no instruction. The control group method was used, as opposed to a pre-test for all subjects, because it was felt that a pretest would serve as an advance organizer, and therefore add an intervening variable to the study. This intervening effect was of a particular concern for this study since one of the program embedded strategies was an advance organizer condition.

Learning Task Conditions

The within groups factor represented the different levels of objectives, or learning tasks, and consisted of the five achievement tests to evaluate the amount of information acquired and competency level with learned information. To do this, the five tests ranged in difficulty from a simple memory task to a more difficult problem solving task. Each of the five tests contained a total of 20 possible points, and will be described according to level of intellectual difficulty, simple to difficult.

1) List Learnings Task

The list learning task is a simple memory task, requiring the learner to list the names of the parts of the heart.

2) Spatial Learning Task, Cued-Recall

The spatial learning task, cued-recall, consisted of 20 multiple choice items designed to test the spatial learning of heart part location. The test contained a line drawing of the heart with numbers and arrows indicating where each part was located. The 20 test items appeared under the numbered drawing and required the subject to identify specific parts and locations.

3) Simple Concept learning Task

The simple concept learning task contained 20 multiple choice items. Each item provided in the item stem a description of a critical attribute about a heart part or operation. The learner selected the heart part name or operation name from the available choices.

4) Complex Concept Learning Task

The complex concept learning task contained 20 multiple choice items. The items were complex in the sense that they involved "if-then" relationships of the parts of the heart during heart operation, or what could be defined as disjunctive concepts.

5) Spatial Learning Problem, Free-Recall

The spatial learning problem, free recall was considered the most difficult of the five tasks. The learner had to prepare from memory a line drawing of the heart, with the parts in the correct location and labeled. Then the learner had to indicate blood flow through the heart pump system, by drawing a series of dotted lines connecting how the parts interact during heart operation.

The tests were administered off-line, and in a sequence that eliminated cues for the free recall conditions; list learning and spatial learning problem.

Subjects participating in the study were first term freshmen enrolled in a beginning level General Psychology course at Ohio State University. Subjects received course credit for participation in the study, but had to complete all phases of the study to receive credit. There were 180 subjects participating in the study, all of these subjects were randomly distributed to the 8 instructional conditions and 1 control condition. Subjects were directed to arrive at the experiment's location on campus at a specific day and time over two consecutive days. Sixteen hours were blocked off over two days to complete the study. Two hours of time were provided for each instructional condition, cognitive tests, and post-tests.

There were 20 subjects in each instructional condition, and the control group. Subjects were assigned to work in the two computer rooms, each computer room had a proctor. All subjects started their instructional program at the same time and were required to work through the instructional program independently. Prior to beginning the program the Barratts was administered on-line. All three parts of the Barratts were given and data collected on each subject. The Barratts took 20-25 minutes to complete, the heart instructional programs took from 25-30 minutes to complete. After completing the MCBI work, subjects were directed to a testing room, and received the five post-tests. The tests were administered by one of the experimenters, and subjects were required to work independently on their test package. All 180 subjects arrived and completed the study. While this seems surprising, the credit received amounts to a significant project in their Psychology course.

Data Analysis and Summary

The analysis of variance results are presented in Table 1. The between subject variable of Instructional Condition resulted in a significant F-ratio, as did the within subjects variable Test Type. However, there was a significant interaction between Instructional Condition and Test Type, so the main effect mean scores will not be analyzed with a follow-up analysis method.

The overall table of mean scores are presented in Table 2. A descriptive analysis of Table 2 indicated that the Externally Paced (EP) conditions using the program embedded learning strategies tended to have better overall mean scores, when compared to the Self-Paced (SP) conditions using program embedded strategies. The EP plus Imagery Cue Strategy tended to have higher mean scores accross learning tasks, and the EP plus Attention Directing Strategy was close to this performance level. The Imagery Cue Strategy and Attention Directing Strategy, used in conjunction with the EP MCBI design, tended to have superior overall test scores than did the SP MCBI conditions using the same program embedded strategy. The beneficial effect of the Imagery Cue Strategy, and Attention Directing Strategy with the EP design, was strongest for the spatial learning tasks of Spatial Learning Cued Recall, and Spatial Learning Problem. The EP plus program embedded learning strategies overall mean score on the Spatial Learning Cued Recall task was (13.17) compared to the SP score of (10.92) using program embedded strategies. On the Spatial Learning Problem the EP plus program embedded strategies score overall was (10.67), compared to the SP only, and SP plus program embedded strategies score overall of (7.94). The EP using both strategies, of Imagery Cue and Attention Directing, had the highest mean scores on the Spatial tasks; Spatial Learning Cued Recall (13.40), Spatial Learning Problem (12.10). Another interesting finding in Table 2, is the similarity between SP and EP performance when program embedded strategies are not used. Further, note that the Imagery Cue Strategy and Attention Directing Strategy seemed to have improved learning more effectively for the EP, MCBI design, and not for the SP, MCBI design. An additional interesting result, in this descriptive analysis of Table 2, is the high scores on the List Learning task for the EP, plus Imagery Cue and Attention Directing Strategies, and the EP plus Imagery Cue Strategy (13.55; 14.35). This seems to indicate that imagery may be beneficial to list learning of verbal information. Finally, the descriptive analysis of Table 2, indicates that the Control Group had little or no knowledge of heart physiology with an overall mean score of (4.79).

The follow-up analysis appears in Table 3, and figure 2 presents a graph of the interaction. A Tukey follow-up analysis was used with an Alpha set at (.01). Looking at Table 3, the reader will find a listing of all mean comparisons within each instructional condition. The 8 instructional conditions are represented, with 10 comparisons, representing each learning task score in each column. Significant mean differences are in parenthesis. Note that the mean scores have a letter subscript indicating which learning task they represent; (List = L, Spatial Cued = S, Simple Concept = SC, Complex Concept = CC, Spatial Problem = SP).

Looking at the pattern of means for the SP and EP instructional conditions finds a similar set of scores. The EP conditions using the program embedded strategies of an Imagery Cue Strategy and Attention Directing Strategy have significantly different patterns of mean scores, favoring the use of these strategies for spatial learning tasks. Looking at figure 2 reveals the source of this difference. Note the higher mean scores on the (EP + IC, AD), (EP + IC) and (EP + AD) conditions compared to the EP, SP, and (SP + IC, AD), (SP + IC) and (SP + AD) conditions, on the Spatial Learning Problem. While not as strong a difference, the EP, and EP plus program embedded strategy conditions had higher scores, than the SP, and SP plus program embedded strategy conditions on the Spatial Learning Cued Recall Task.

So clearly this pattern of means indicates that the program embedded strategies of Imagery Cue Strategy and Attention Directing Strategy are beneficial for Spatial Learning Tasks. The Imagery Cue Strategy, in combination with the Attention Directing Strategy, seems to have the most beneficial effect on acquiring spatial information, and is somewhat helpful for learning lists of verbal information. It is likely, that the Imagery Cue Strategy is beneficial because of the memory effects of forming and manipulating mental images during learning. This would have its strongest impact on performance tasks requiring the reconstruction of visual or spatial information, and the analysis of spatial relationships. This, of course is exactly what the Spatial Learning Task required. The Attention Directing Strategy probably aided the learner in identifying relevant from irrelevant, or background information, and had the same effect as an advance organizer. An interesting result is that the Imagery Cue Strategy and Attention Directing Strategy was helpful to those in the EP, MCBI conditions on all learning tasks, visual and verbal, but did not seem to help those in the SP, MCBI conditions. This is a particularly significant result. Note that the pattern of means for the SP, MCBI conditions using the program embedded strategies is different, indicating lower mean scores, than the EP, MCBI conditions using the same strategies. However, the SP only group had a similar performance on the verbal learning tasks (Simple Concept & Complex Concept) as did the EP plus program embedded strategies groups, but a poorer performance on the spatial learning tasks (Spatial Cued and Spatial Problem). It is likely that the SP conditions adopted their own learning strategies, and for college students dealing with verbal learning tasks, these were effective. It seems that the EP groups were more willing to use available program embedded strategies.

The results of this study partially supported hypotheses 1, indicating that the EP, MCBI design is superior to the SP, MCBI design for some learning tasks. Hypothesis 2 was supported by these results, indicating that the Imagery Cue Strategy did improve the learning of spatial information. Hypothesis 3 was supported indicating that the Attention Directing Strategy can improve learning, by operating like an advance organizer. Hypothesis 4 was supported indicating that the Imagery Cue Strategy and Attention Directing Strategy, in combination can improve the learning of spatial information, over either strategy alone. Finally, Hypothesis 5 was supported, finding different effects on the use of program embedded strategies. The use of program embedded learning strategies seems to be less effective for the SP-MCBI design, and more effective for the EP-MCBI design.

Conclusion

The results of this study indicate that program embedded strategies can be effective in acquiring certain types of information, with certain types of MCBI designs. If spatial information is an important part of what should be learned, an Imagery Cue Strategy can help learning. The formation and manipulation of mental images can help the learner acquire information of a spatial nature and reconstruct that information from memory, for later recall and application. Strategies that serve as advance organizers can be particularly helpful in pointing out relevant to-be-learned information. While the Attention Directing Strategy amounted to a 5-second time delay, this gave the learners enough of a cue to concentrate on the relevant visual information. Of course, it is logical that these strategies in combination would provide a more potent learning effect, since advance organizers, and an imagery strategy, would help the learner identify what to learn and significantly aid memory. The Imagery Cue Strategy and Attention Directing Strategy can help learning, and in particular the learning of visual information from MCBI. However, they seem to have their most beneficial effect with an EP-MCBI design, not an SP-MCBI design. The EP-MCBI design seems to allow the learner to better adapt to program embedded strategies, and learn more using these strategies. It is not known why this occurred, the only hypothesis currently is that the SP-MCBI design groups, may have been trying to use their own strategies, which were inconsistent with the program embedded strategies.

From a practical point of view the results of this study clearly indicate that program embedded strategies can help learning, particularly if they are related to psychological factors. In the present study the psychlogical factors these strategies related to were imagery, and the advanced organization of information in the cognitive structure. In addition, the External Paced MCBI design provides for better adaptation of these program embedded strategies, than Self Paced. From a research point of view these results can lead to additional studies on other cognitive based learning strategies, alternative MCBI designs, and effects upon different learning tasks and materials further work should also be done on MCBI design types, learning strategies, and cognitive style variables.

Between Subjects	MS	DF	F-Ratio	Probability
Instruction Condition (A) (MCBI Program)	527.65	8	7.881	.0001
Error Between	66.95	171	-----	-----
Within Subjects				
Test Type (B)	366.00	4	63.348	.0001
(A) x (B) (Interaction)	30.41	32	5.264	.0001
Error Within	5.78	684	------	-----

Anovr Summary, Table 1.

	SP	SP, IC+AD	SP, IC	SP, AD	EP	EP IC+AP	EP, IC	EP, AD	C	Main Effect Within	Control Group Out
List	12.0	13.0	12.60	12.15	12.10	13.55	14.35	12.60	2.7	11.67	12.79
Spatial Cued	12.20	11.30	10.85	10.60	12.45	13.40	12.85	13.25	6.15	11.45	12.11
Simple Concept	12.30	9.0	10.40	9.60	11.30	10.70	12.70	11.35	6.8	10.46	10.92
Complex Concept	11.80	9.15	10.65	10.50	12.80	11.45	11.90	10.75	7.4	10.71	11.13
Spatial Problem	8.25	8.8	7.80	6.9	8.15	12.10	10.60	9.30	.9	8.09	8.99
Main Effect Between	11.31	10.25	10.46	9.95	11.36	12.24	12.48	11.45	4.79	------	------

Table of Main and Simple Effect Means, Table 2.

Simple Effect Means

SP	SP+IC+AD	SP+IC	SP+AD	EP	ED+IC+AD	EP+IC	EP+AD
$12_L-12.2_S=$ .20	$13_L-11.3_S=$ 1.7	$12.6_L-10.85_S=$ 1.75	$12.15_L-10.6_S=$ 1.55	$12.1_L-12.45_S=$ .35	$13.55_L-13.4_S=$ .15	$14.35_L-12.85_S=$ 1.5	$12.6_L-13.25_S=$ .65
$12_L-12.3_{sc}=$ .30	$13_L-9.0_{sc}=$ (4.0)	$12.6_L-10.4_{sc}=$ 2.2	$12.15_L-9.6_{sc}=$ (2.55)	$12.1_L-11.3_{sc}=$ .80	$13.55_L-10.7_{sc}=$ (2.85)	$14.35_L-12.7_{sc}=$ 1.65	$12.6_L-11.35_{sc}=$ 1.25
$12_L-11.8_{cc}=$ .20	$13_L-9.15_{cc}=$ (3.85)	$12.6_L-10.65_{cc}=$ 1.95	$12.15_L-10.5_{cc}=$ 1.65	$12.1_L-12.8_{cc}=$ .70	$13.55_L-11.45_{cc}=$ 2.1	$14.35_L-11.9_{cc}=$ 2.45	$12.6_L-10.75_{cc}=$ 1.85
$12_L-8.25_{sp}=$ (3.75)	$13_L-8.8_{sp}=$ (4.2)	$12.6_L-7.8_{sp}=$ (4.8)	$12.15_L-6.9_{sp}=$ (5.25)	$12.1_L-8.15_{sp}=$ (3.95)	$13.55_L-12.1_{sp}=$ 1.45	$14.35_L-10.6_{sp}=$ (3.75)	$12.6_L-9.3_{sp}=$ (3.3)
$12.2_s-12.3_{sc}=$ .10	$11.3_s-9.0_{sc}=$ 2.3	$10.85_s-10.4_{sc}=$ .45	$10.6_s-9.6_{sc}=$ 1.0	$12.45_s-11.3_{sc}=$ 1.15	$13.4_s-10.7_{sc}=$ (2.7)	$12.85_s-12.7_{sc}=$ .15	$13.25_s-11.35_{sc}=$ 1.9
$12.2_s-11.8_{cc}=$ .40	$11.3_s-9.15_{cc}=$ 2.15	$10.85_s-10.65_{cc}=$ .20	$10.6_s-10.5_{cc}=$ .10	$12.45_s-12.8_{cc}=$ .35	$13.4_s-11.45_{cc}=$ 1.95	$12.85_s-11.9_{cc}=$ .95	$13.25_s-10.75_{cc}=$ (2.5)
$12.2_s-8.25_{sp}=$ (3.95)	$11.3_s-8.8_{sp}=$ (2.5)	$10.85_s-7.8_{sp}=$ (3.05)	$10.6_s-6.9_{sp}=$ (3.70)	$12.45_s-8.15_{sp}=$ (4.30)	$13.4_s-12.1_{sp}=$ 1.3	$12.85_s-10.6_{sp}=$ 2.25	$13.25_s-9.3_{sp}=$ (3.95)
$12.3_{sc}-11.8_{cc}=$ .50	$9.0_{sc}-9.15_{cc}=$ .15	$10.4_{sc}-10.65_{cc}=$ .25	$9.6_{sc}-10.5_{cc}=$ .90	$11.3_{sc}-12.8_{cc}=$ 1.50	$10.7_{sc}-11.45_{cc}=$ .75	$12.7_{sc}-11.9_{cc}=$ .80	$11.35_{sc}-10.75_{cc}=$ .60
$12.3_{sc}-8.25_{sp}=$ (4.05)	$9.0_{sc}-8.8_{sp}=$ .20	$10.4_{sc}-7.8_{sp}=$ (2.6)	$9.6_{sc}-6.9_{sp}=$ (2.7)	$11.3_{sc}-8.15_{sp}=$ (3.15)	$10.7_{sc}-12.1_{sp}=$ 1.4	$12.7_{sc}-10.6_{sp}=$ 2.1	$11.35_{sc}-9.3_{sp}=$ 2.05
$11.8_{cc}-8.25_{sp}=$ (3.55)	$9.15_{cc}-8.8_{sp}=$ .35	$10.65_{cc}-7.8_{sp}=$ (2.85)	$10.5_{cc}-6.9_{sp}=$ (3.6)	$12.3_{cc}-8.15_{sp}=$ (4.65)	$11.45_{cc}-12.1_{sp}=$ .65	$11.9_{cc}-10.6_{sp}=$ 1.3	$10.75_{cc}-9.3_{sp}=$ 1.45

Simple Effects; Table 3.

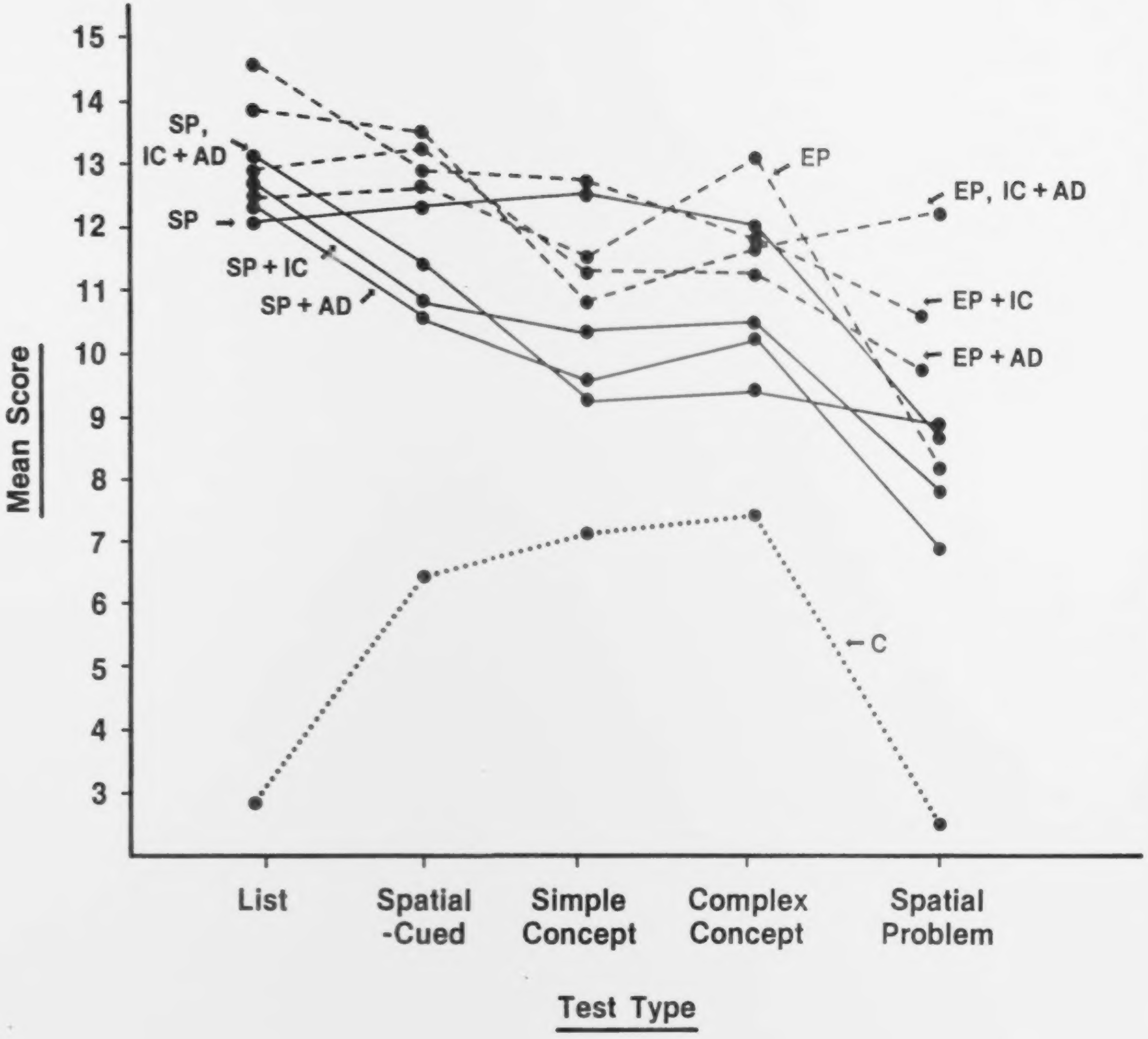
Alpha = (.01)
Significant Differences = ( )

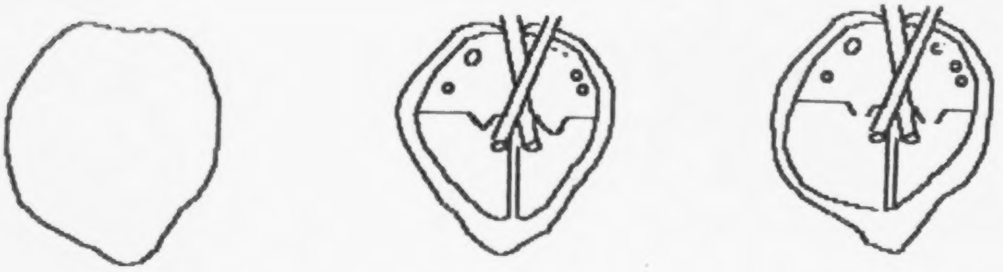
List=L, Spatial Cued=S, Simple Concept=SC
Complex Concept=CC, Spatial Problem=SP

SP=Self Paced; EP=Externally Paced; IC=Image Cue Strategy; AD=Attention Directing Strategy

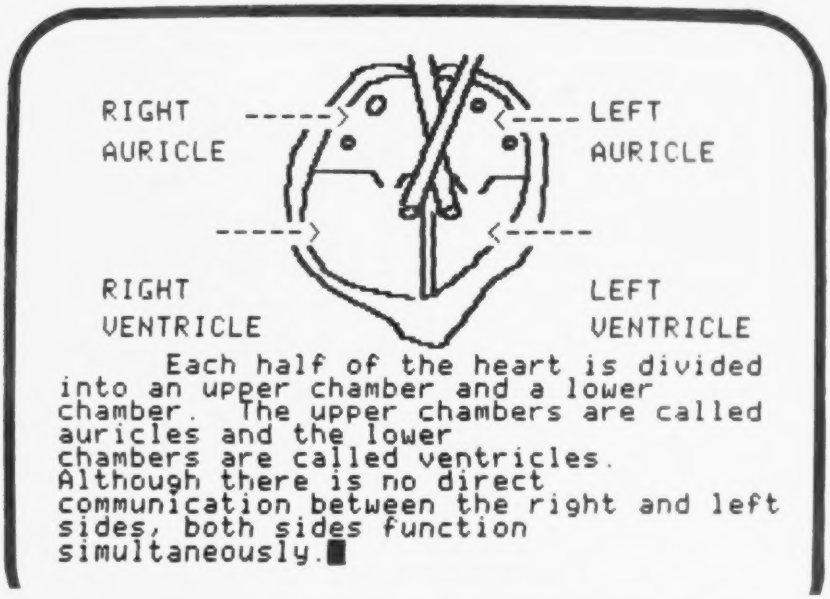
	SP	SP, IC+AD	SP, IC	SP, AD	EP	EP, IC+AD	EP, IC	EP, AD	Control
List Learning	Ref./Imp.	R/I	R/I	R/I	R/I	R/I	R/I	R/I	R/I
Spatial Learning Cued Recall									
Simple Concept Learning									
Complex Concept Learning									
Spatial Learning Problem									

Figure 1 - Overall Experimental Design


Mean Score
15
14
13
12
11
10
9
8
7
6
5
4
3
SP,
IC + AD
SP
SP + IC
SP + AD
EP
EP, IC + AD
EP + IC
EP + AD
C
List
Spatial
-Cued
Simple
Concept
Complex
Concept
Spatial
Problem
Test Type



HEART CONTRACT! WHOLEHEART!


RIGHT
AURICLE
LEFT
AURICLE
RIGHT
VENTRICLE
LEFT
VENTRICLE

Each half of the heart is divided into an upper chamber and a lower chamber. The upper chambers are called auricles and the lower chambers are called ventricles. Although there is no direct communication between the right and left sides, both sides function simultaneously.█

Figure 3 - Sample heart visual types,
and Sample Complete
Instructional Display.

References

Ausubel, D.P Educational Psychology, A Cognitive View, NY: Holt, Rinehard and Winston, Inc. 1968.

Belland, J.; Taylor, W.; Canelos, J.; Dwyer, F.; Baker, P. Is the Self-Paced Instructional Program, Via Microcomputer-Based instruction, the most effective method of addressing individual learning differences, ECTJ V-33, No.3, pp - 185-198, 1985b.

Canelos, J., The Effects of three levels of Visual Complexity on the information Processing of Field-Dependents and Field-Independents when acquiring Instructional Information forPerformance on three types of Educational Objectives. AECT Convention, Denver, Co., Research and Theory Division Proceedings, pp. 85 - 97, 1980a.

Canelos, J.; Taylor, W.; Gates, R. The Effects of three Levels of Visual Stimulus Complexity on the Information Processing of Field-Dependents and Field-Independents when Acquiring Information for Performance on Three Types of Instructional Objectives, J. Instructional Psychology, V-3, No.2, pp. 65 - 70, 1980b.

Canelos, J.; Taylor, W.; A Networking Information Processing Strategy and the Learning of Field-Dependents Receiving Visual Instructional Information, J. Experimental Education, V-50, No.1, pp. 40 - 46, 1981.

Canelos, J.; Taylor, W.; Altschuld, J. Networking vs. Rote Learning Strategies in Concept Acquisition. ECTJ, V-30, No.3, pp. 141 - 150, 1982.

Canelos, J. Young Researcher Award, Acceptance Presentation, AECT Convention Dallas, TX., Research and Theory Division Proceedings. pp. 163 - 182, 1982.

Canelos, J. The Instructional Effectiveness of Three Content-Independent Imagery Learning Strategies and Visualized Instruction of Varying Complexity, J. Experimental Education, V-51, NO.2, pp. 58 - 68, 1983.

Canelos, J.; Taylor, W.; Dwyer, F.; The Effects of Recall Cue and cognitive Trace Compatibility When Learning from Mediated Instruction. AECT Convention, Dallas, TX., Research and Theory Division Proceedings, pp. 72 - 98, 1984.

Canelos, J.; Baker, P.; Taylor, W.; Belland, J.; Dwyer, F. External Pacing as an Instructional Strategy for the Design of Micro-Computer Based Instructional Programs to Improve Performance on Higher Level Instructional

Objectives, AECT Convention Las Vegas, Nevada. Research and Theory Division Proceedings, pp. 65 - 84, 1986.

Carrier, C. Do Learners Make good Choices? Feb., Instructional Innovator, pp. 15 - 17, 1984

Dwyer, F.; Taylor, W.; Canelos, J.; Bellard, J.; Baker, P. Varied Self-Paced Micro-Computer Based Instructional Programs for Addressing Individual Differences When Acquiring Different Levels of Instructional Objectives AECT Convention, Anaheim, CA., Research and Theory Division Proceedings, pp. 146 - 163, 1985a.

Dwyer, F.; Canelos, J.; Research Justification and Implementation of the Program of Systematic Evaluation, State College, PA.: Learning Services, Inc., in press 1987.

Kosslyn, W. Information Representation in Visual Imagery. Cognitive Psychology, V-7, 307-318, 1975.

Paivio, A. On the functional Significance of Imagery. Psychological Bulletin, v-73, pp. 385 - 392, 1970.

Reiser, R. A. Reducing Student Procrastination in Personalized System of Instruction Course, ECT , V-32, pp. 41 - 49, 1984.

Rothkopf, E. Z. et. al, Selective facilitative effects of interspersed questions on learning from written materials, Educational Psychology, v-58, pp. 56 - 61, 1967.

FIELD DEPENDENCE-INDEPENDENCE AND LEARNING FROM INSTRUCTIONAL TEXT

by

Merton E. Thompson
University of Wisconsin-Stevens Point
438 COPS Building
Stevens Point, Wisconsin 54481

and

Marcia E. Thompson
Indiana University
1409 Canterbury Drive
Stevens Point, Wisconsin 54481

Although the existence of individual differences has been documented for many years, very little is known about how these differences relate to the learning process. One variable that has received intensive study is field dependence-independence (FDI). Field dependence-independence is a continuum. An individual at one end of the continuum is governed to a large extent by the organization of the field. This individual is referred to as field dependent. On the opposite end of the continuum, the field independent individual, is characterized by an articulated cognitive style. This person analyzes and structures experiences depending upon the task at hand and is not as easily influenced by the organization of the field.

Through years of research and observation a number of characteristics of field independent and field dependent individuals have been determined. Many of those characteristics which have an impact upon learning are listed in Table 1.

Table 1
Characteristics of Field Independents and Field Dependents

Field Independents	Field Dependents
1. Impose organization on unstructured field.	1. Take organization of field as given.
2. Have a sense of separate identity and internalized values and are independent of social field.	2. Rely on others for self definition and differentiation and are attentive to social stimuli.
3. Sample fully from the nonsalient features of a concept in order to attain the relevant attributes and to form hypotheses.	3. Dominated by the most salient features of a concept in the attainment of the relevant attributes and in hypothesis formation. Can sample fully from set of features if they are in discrete form.
4. Utilize the active approach to learning, the hypothesis testing mode.	4. Utilize the passive approach to learning, the intuitive mode.
5. Learning curve is discontinuous--no significant improvement in learning a new concept until the appropriate hypothesis is found, then sudden improvement.	5. Learning curve is continuous--gradual improvement as relevant cues are sampled.

6. Use mnemonic structures and reorganize materials for more effective storage and retrieval of information.	6. Use existing organization of materials in cognitive processing.
7. Less susceptible to inference from outside influences.	7. Particularly susceptible to social influence on test of conformity and suggestibility.
8. Learn to generalize to object and design concepts more readily.	8. Less effective in generalizations from original designs to variations on basis of common components.
9. Prefer to learn general principles and acquire them more easily.	9. Prefer to learn specific information and acquires it more easily.
10. Learn more in the absence of external reward and punishment when intrinsic motivation is present.	10. Learn more under conditions of negative social reinforcement.
11. Limited reference to other's views may make field independents impervious to helpful information.	11. Have greater recourse to external sources of information in arriving at attitudes and judgments.
12. Use wholeist strategy.	12. Use partist strategy.
13. Stress has less effect on memory.	13. Stress tends to impair memory, threatening material more likely to be repressed.
14. Draw the human figure in a more articulated fashion.	14. Draw the human figure in a less articulated fashion.

Neither end of the continuum is clearly superior in concept attainment or other aspects of learning and that value judgments should not be associated with either mode. FDI is related much more closely to how people learn than to how much is learned.

Fleming and Levie (1978) pointed out that performance on a learning task is more rapid if the salient cues are relevant and less rapid if the salient cues are irrelevant to the learning task. Since field dependents tend to be dominated by salient cues, and ignore nonsalient cues, Goodenough (1976) hypothesized that when the salient cues are relevant, field dependents would learn the material at least as easily as field independents since they (field dependents) pick out the salient cues for processing. He further suggested that field dependents might learn the material more easily under these conditions due to their reliance on salient cues. Witkin et. al., (1977) found that field dependent people are aided by materials that provide structure. The more structured the mediator, the more that field dependent person's performance was helped. This study also found that field independents are generally unaffected by additional structure and are not hindered by its presence.

Very few other studies that looked for interactions between FDI,instructional differences, and educational outcomes have been conducted. Kogan (1979) summed up his reaction to the information available on this individual difference variable by saying:

> [F]ield dependence style might prove useful in understanding students' academic choices and teacher-learner processes more broadly conceived even though there may be defects in field dependence theory itself.(p. 32).

The Study

This study was an attempt to determine if there is a relationship between field dependence-independence one specific aspect of the learning process. The specific aspect chosen for study was the ability of individuals to read and answer questions over information delivered in the form of printed text.

An attempt was also made to determine, if FDI does affect the cognitive processing of text, how the effect is manifested. Specifically, this study attempted to determine how the structure of instructional text can aid the learning process of individuals who are at various points on the continuum of FDI.

Hypotheses

Based upon the literature, the following hypotheses were developed:

1. There would be a significant difference between field dependent participants and field independent participants on scores of tests over instructional text with center and side headings and without center and side headings.

2. Field independent participants would score significantly higher than field dependent participants

on tests over instructional text when the instructional text does not contain center and side headings.

3. Field dependent participants would score at least as well as field independent participants on tests over instructional text when the instructional text contain center and side headings.

Methodology

The participants for the study were 96 students at the University of Wisconsin-Stevens Point. The group consisted of 30 males and 66 females who ranged in age from 18 to 38 years. Thirty fields of study were represented.

The Group Embedded Figures Test (GEFT) was administered to classify the participants on the FDI variable. Following this the participants were divided randomly into two groups: one half received a selection of instructional text containing key words used as center and side headings; the other half received the same instructional text minus the center and side headings. After reading the instructional text, each participant took a short objective test covering important aspects of the instructional text.

The instructional text, "Panorama by Candlelight", was taken from the February 24, 1947 issue of Time magazine. This time period was chosen so that none of the participants were likely to have had any previous detailed knowledge of the topic of the article. A news magazine was selected because the writing level is within the reading level of the participants and the writing style is informative in nature. The test over the instructional text consisted of 16 multiple choice questions and was produced by the author and pilot-tested prior to the study to establish reliability.

Results

The range of scores on the GEFT was from 0 to 18. Those scoring 0 found none of the simple figures embedded in the complex figures. Those scoring 18 found all 18 simple figures in the complex figures. The median for the test was 13.5.

The scores on the instructional text test ranged from 3 to 14. A score of 3 means that the participant answered 3 of the 16 question correctly. A score of 14 means the participant answered 14 of 16 correct.

Using Statistical Programs for the Social Sciences (SPSS), an analysis of variance was performed on the data. The participants were divided by using the median of the GEFT scores. Those scoring below the median were classified as field dependent and those scoring above the median were classified as field independent. The form of the instructional text, with and without headings, was the other independent variable, producing a 2x2 matrix with cell sizes ranging from 23 to 25 .

Table 2
Cell Size for GEFT score x Article Version

	Without Headings	With Headings
Field Independent	24	23
Field Dependent	25	24

Because the cell sizes are not equal but are proportional to the frequencies of each factor, the analysis of variance was conducted using a hierarchical approach. The means for each of the four cells are shown in Table 3. The results of the two-way ANOVA with GEFT score and article version is shown in Table 4.

Table 3
Mean Scores for GEFT x Article Version

	Without Headings	With Headings
Field Independent	10.5	9.3
Field Dependent	8.6	9.4

Table 4
ANOVA for GEFT x Article Version

Source of Variation	Sum of Squares	DF	Mean Square	F	Sign.
Main Effects	18.94	2	9.47	1.48	.23
Version	.69	1	.69	.11	.74
GEFT	18.25	1	18.25	2.86	.09
2-way Interactions	25.32	1	24.32	3.80	.05
Version GEFT	25.32	1	24.32	3.80	.05
Explained	43.26	3	14.42	2.26	.09
Residual	588.23	92	6.39		
Total	631.49	95	6.65		

This indicates that there is a relationship between how people score on the Group Embedded Figures Test and how they score on a test over instructional text with and without center and side headings and that the hypotheses can be accepted. There was a significant difference at the .05 level using the two-way ANOVA. In addition, the differences were in the direction predicted by the author. Field independent participants did significantly better than field dependent participants when the article contained no center and side headings. Field independent participants scored lower than field dependent participants on the article test when given center and side headings.

Those scoring above the median on the GEFT scored higher on the instructional text test than those scoring below the median on the GEFT when the instructional text did not contain center and side headings GEFT. Those scoring below the median on the GEFT scored higher on the test than those scoring above the median on the GEFT when given instructional text with center and side headings. The field dependent participants who received the version with headings and the field independent participants who received the version without the heading statistically scored the same on the test.

Conclusions

Based upon these results, it is possible to conclude that for the field dependent participants in the study, the presence of center and side headings improved their scores on the instructional text. This is consistent with the theory set forth by Goodenough (1976) that when salient cues, in this case, the center and side headings, are present, field dependent participants would learn the material as easily as field independents.

The findings for the field independents, however, are not consistent with the theory that salient clues will increase learning, put forth by Fleming and Levie (1978). The findings also run counter to the Witkin's et. al. (1977) theory that field independents ignore additional structure and are not be affected by it. In this study, field independents scored higher on the instructional text test when given the text without the headings. The apparent conflict with Fleming and Levie is possibly due to the fact that they were not looking at individual differences in developing their message design principles, but were looking at responses of people in general. In the case of the difference between the Witkin's et. al. theory and the results found here, it would seem to be indicated that this area needs continued study with a variety of groups of participants. It is possible that an imposed structure may interfere with the structure a field independent participant develops cognitively, this type of explanation is beyond the scope of this study.

The sample was drawn from students at a Midwestern university of approximately 9000 students. Although caution has to be exercised in generalizing from this population to a larger population of college students, the results of the GEFT test are similar to the norms published in the GEFT manual.

The sample used in this study had a high ratio of females vs. males. Because gender has been linked to FDI in many previous studies, this may introduce a confounding factor.

The results indicate that for the FDI variable it does make a difference on immediate test scores whether the instructional text contains center and side headings. Although the actual difference in mean scores is small, the direction of the results is clear. Educators should begin to consider differences between individuals when presenting information in the form of instructional text. Perhaps with the isolation of other individual difference variables which influence learning, the improvement in test scores can be magnified.

Suggestions for Future Research

The results presented here suggest several areas of additional research. One logical extension of this study would be to determine if the differences found here for FDI and text version is consistent when the instructional text is presented via CRT screens. Structuring paper handouts for students individually is a cumbersome process and therefore one not likely to see widespread use. If, on the other hand, the information is presented by CRT screen, the restructuring can be incorporated into the CRT screen program and individuals can receive the version most appropriate to them.

BIBLIOGRAPHY

Annis, L. F. Effect of congitive style and learning passage organization on study technique effectiveness. Journal of Educational Psychology, 1979, 71, 620-626.

Ausburn, L. J. & Ausburn, F. B. Cognitive styles: Some information and implications for instructional design. Educational Communications and Technology Journal, 1978, 26, 337-354.

Brooks, L. R. The suppression of visualization by reading. Quarterly Journal of Experimental Psychology, 1967, 19, 289- 299.

Broverman, D. M. Cognitive style and intra-individual variation in abilities. Journal of Personality, 1960, 28, 240-256.

Cronbach, L. J. How can instruction be adapted to individual differences? In R. M. Gagne (Ed.) Learning and Individual Differences. Columbus, Ohio: Charles E. Merrill, 1967.

Cronbach, L. J. & Snow, R. E. Aptitudes and instructional methods. New York: Halstead Press, 1977.

Davis, J. K. & Frank, B. M. Learning and memory of field dependent-independent individuals. Journal of Research in Personality, 1979, 13, 469-479.

Di Vesta, F. J. Theory and measures of individual differences in studies of trait by treatment interaction. Educational Psychologist, 1973, 13, 5-12.

Di Vesta, F. J. Trait-treatment interactions, cognitive processes, and research on communication media. AV Communication Review, 1975, 23, 185-196.

Fantini, M. D. A contemporary approach to individualization. Theory into Practice, 1980, 19, 28-31.

Fitzgibbons, D. J. & Goldberger, L. Task and social orientation: a study of field dependence, "arousal", and memory of incidental material. Perceptual and Motor Skills, 1971, 32, 167-174.

Fleming, M. & Levie W. H. Instructional Message Design. Englewood Cliffs, N. J.: Educational Technology Publications, 1978.

Gardner, R. W., Holzman, P. S., Klein, G. S. Linton, H. B. & Spence, D. P. Cognitive control: A study of individual consistencies in cognitive behavior. *Psychological Issues*, 1. New York: International Universities Press, 1959.

Gardner, R. W., Jackson, D. N. & Messick, S. J. Personality organization in cognitive controls and intellectual abilities. *Psychological Issues*, 2 (4). New York: International Universities Press, 1960.

Gardner, R. W. & Lohrenz, L. J. Some old and new group tests for the study of cognitive controls and intellectual abilities. *Perceptual and Motor Skills*, 1969, 29, 935-950.

Glaser, R. Individuals and learning: The new aptitudes. *Educational Researcher*, 1972, 1 (6), 5-13.

Goldman, S. R., Pellegrino, J. W., Parseghian, P. & Sallis, R. Developmental and individual differences in verbal analogical reasoning. *Child Development*, 1982, 53, 550-559.

Goodenough, D. R. The role of individual differences in field dependence as a factor on learning and memory. *Psychological Bulletin*, 1976, 83, 675-684.

Hettema, J. Cognitive abilities as process variables. *Journal of Personality and Social Psychology*, 1968, 10, 461-471.

Johnson, S., Flinn, J. M. & Tyer, A. E. Effect of practice and training in spatial skills on embedded figures scores of males and females. *Perceptual and Motor Skills*, 1979, 48, 975-984.

Kogan, N. Cognitive style: Implications for education. Address delivered during the National Conference on Educational Choices in Omaha, Nebraska, 1979.

Masson, M. E. J. & Miller J. A. Working memory and individual differences in comprehension and memory of text. *Journal of Educational Psychology*, 1983, 75, 314-318.

Misanchuk, E. R. & Schwier, R. A. Learner analysis and the designer of instructional materials: An invitation to involvement in research. *Performance and Instruction*, 1981, 20 (2), 5-7.

Provost, G. L. Teaching strategies, modes of evaluation and field-dependence factor. Perceptual and Motor Skills, 1981, 52, 163-173.

Reardon, R., Jolly, E. J., McKinney, K. D. & Forducey, P. Field dependence/independence and active learning of verbal and geometric material. Perceptual and Motor Skills, 1982, 55, 263-266.

Snow, R. E. & Salomon, G. Aptitudes and instructional media. AV Communication Review, 1968, 16, 341-357.

Thorndike, E. L. Individuality. Boston: Houghton Mifflin, 1911.

Thornel, J. G. Individual differences in cognitive styles and the guidance variable in instruction. Journal of Experimental Education, 1977, 45 (4), 9-12.

Vernon, P. E. The distinctiveness of field dependence. Journal of Personality, 1972, 40, 366-391.

Wachtel, P. Field-dependence and psychological differentiation: Reexamination. Perceptual and Motor Skills, 1972, 35, 179- 189.

Washburne, C. W. Introduction and summary. In C. W. Washburne (Dir.) Adapting the Schools to Individual Differences, Twenty-fourth Yearbook of the National Society for the Study of Education, Part II, Bloomington, Ill.: Public School Publishing Company, 1925.

Witkin, H. A. Studies in space orientation: IV. Further experiments on the perception of the upright with displaced visual fields. Journal of Experimental Psychology, 1948, 38, 762-782.

Witkin, H. A. Cognitive styles in the educational setting. New York University Education Quarterly, 1977, 8, 14-20.

Witkin, H. A. & Goodenough, D. R. Field dependent-field independent cognitive styles and their educational implications. Review of Educational Research, 1977, 47, 1- 64.

Witkin, H. A., Moore, C. A., Goodenough, D. R. & Cox, P. W. Field-dependent and field-independent cognitive styles and their educational implications. Review of Educational Research, 1977, 47, 1-64.

Application of Schema Theory to the Instruction of Arithmetic Word Problem Solving Skills

Chia-jer Tsai
Department of Educational Research

Sharon J. Derry
Department of Psychology

Florida State University
Tallahassee, FL 32306

Running head: ARITHMETIC WORD PROBLEM SOLVING SKILLS

Abstract

Word problems is an important area in arithmetic education. Conventional approaches for teaching word problems have serious drawbacks and may develop unreliable skills. The TAPS project instead uses an understanding-based approach. Four schemas of word problems are identified and analyzed. An information-processing model of word problem solving is also hypothesized. A diagnostic test and instructional program are being developed based on the schema theory. A powerful intelligent tutoring system for drill-and-practice is also incorporated in the instructional program.

Introduction

Word-problem solving is recognized as an important and special area in arithmetic education. As the name indicates, it requires problem solving skills. Students have to integrate much knowledge and rule-using to perform this skill. More significance of word problems comes from another feature of them. Word problems are verbal simulation of arithmetic applications to real world situations. By doing word problems, students prepare for using their arithmetic skills in the real world.

Conventional Instructional Approach

The common practice of word-problem instruction is operation- and number-oriented. The instruction is given in the context of arithmetic operations for different types of numbers. After students have learned to perform an operation with a certain type of number, e.g., natural numbers, they practice solving word problems which contain the type of number and require the operation. Beside practicing applying the arithmetic operations they have learned, students are usually taught to use certain key words to identify the correct operations for word problems.

The conventional approach to teaching word problems has some serious drawbacks. The required arithmetic operation required by a word problem is dependent on which information the problem requests. The solution procedure may also be dependent on this factor. Therefore knowledge based on arithmetic operations or number types is not a reliable basis of word-problem solving skills. The key-word method has the same weakness. Key words are sometimes valid cues of solutions and sometimes not. Students can be "tricked" to choose an incorrect operation if they rely totally on key words to solve word problems (Webb, 1984). The key-word method is also ineffective for complex problems.

Understanding-Based Approach

Recently researchers emphasize the importance of understanding in word problem solving skills (Mayer, 1983; Kintch & Greeno, 1985; Derry, Hawkes, & Tsai, in press).

Understanding is hypothesized to be the construction of an appropriate problem representation upon which problem solving processes can operate successfully (Greeno, 1977).

Semantic schemas as problem representations for simple word problems have been described by researchers (Riley, Greeno, & Heller, 1983; Marshall, 1985). Four schemas proposed were revised and adopted for the TAPS (Training Arithmetic Problem Solving Skills) research project. These schemas are Combine, Compare, Change, and Vary. A schemas is depicted as a network of linked sets. The basic building blocks of a schema are sets (Kintch and Greeno, 1985). A set is a collection of objects. We can analyze a set into information of kind, specification, unit, and quantity of the objects in the set. Information on procedural operations are attached to a schema to indicate the appropriate operations for solving unknown sets of the schema.

Insert Figure 1 about here

Figure 1 shows the diagram of the Change schema. The Change schema represents a situation in which some objects are transferred from one set to the other. The Start sets and the Result sets contain information of the sets before and after the transfer action, respectively. And the transfer set contains information of the objects transferred.

Here is an example of a word problem depicting the Change schema: "Joe had 15 marbles. He gave Tom 3 marbles. How many marbles does Joe have now?" In this problem 15 marbles are the Start set. Its specification is belonging to Joe at an earlier time, object is certainly marble, unit is none, and quantity is 15. The Transfer set is the three marbles. The Result set is the marbles that Joe has now. The quantity of the Result set is the requested goal of this problem. Because Joe is the giver and the Result set is the goal, the required operation is subtraction.

It is hypothesized that in solving a word problem, a good problem solver identifies the schema of the problem, instantiates the slots with problem information and verifies the schema identification, executes the appropriate procedural attachment to generate the numerical answer, and checks to see whether the solution is appropriate. In the case of a complex problem, the problem solver also has to recognize the goal of the problem, chain the schemas in the problem, and use memory-management skills to store and retrieve information as required in the solution process. As a contrast, a poor problem solver suffers from some of the following skill deficiencies: They do not reliably identify schemas of problems; They do not instantiate problem schemas successfully; They do not reliably identify the correct operation based on position of the unknown set in the schema identified; And they are distracted easily by goal-irrelevant information in a problem A poor problem solver may also suffer from schema-chaining and/or memory management deficiencies when they work on complex problems.

The TAPS Instructional Approach

In light of the above theoretical analysis of problem-solving process, the authors and colleagues plan to teach the component skills explicitly in the TAPS instructional program. Figure 2 shows the map of the instructional program which represents component skills of an "expert" problem solver. The lower-level objectives represent training of basic schema knowledge and skills. The higher-level objectives are chaining, strategic, and motivational skills which are necessary for the terminal objective of solving multi-schema problems.

Insert Figure 2 about here

The target population of the TAPS program are elementary school students. These students have reading and computational competencies, but perform poorly in solving word problems. Students entering TAPS will be given a diagnostic test to determine their competencies on objectives of the instructional map. A student who can not perform a skill will be categorized as "deficient" with respect to that skill. When performance is accurate but slow, the student is characterized as an "informed novice." If a student can perform the skill under speed stress reliably, s/he will be labeled as "expert" for that skill.

An individualized curriculum will then be devised by selecting skills from the instructional map that must be learned from scratch or practiced to proficiency. For areas in which the student is deficient, each new skill will be introduced via direct, didactic instruction. Once the skill is learned in a declarative sense, it must then be practiced without speed pressure until performance reaches the level of "informed novice."

Novice performance of a student will be improved further through intensive drill-and-practice monitored by an intelligent tutoring system (ITS) until the rapid, automated performance style of an "expert" has evolved. In collaboration with the authors, the ITS is being developed by Dr. Lois Hawkes and her students in Florida State University. The ITS will be a complex system integrating many component modules. The system will be able to monitor a student and diagnose causes of his or her difficulties, generate problems and prompts to suit the student's needs, solve problems generated and construct a comprehensive solution tree to monitor the student's solution path, and communicate with the student via a natural language interface. Whereas the primary role of the ITS in TAPS is to deliver intensive drill-and-practice, the ITS could eventually control diagnostic testing and the didactic instruction as well.

Conclusion

TAPS represents a new instructional approach explicitly based on schema and information processing theory. New and powerful technology is also being incorporated to implement the instructional program. Experiences from the TAPS project will not only help to advance instructional science but also improve understanding in the area of human cognition.

References

Derry, S. J., Hawkes, L. W., & Tsai, C.-j. (in press). A theory for remediating problem-solving skills of older children and adults. Educational Psychologist.

Greeno, J. G. (1977). Processes of understanding in problem solving. In N. J. Castellan, D. B. Pisoni, & G. R. Potts (Eds.), Cognitive theory (Vol. 2, pp. 43-83). Hillsdale, NJ: Erlbaum.

Kintch, W., & Greeno, J. G. (1985). Understanding and solving word arithmetic problems. Psychological Review, 92, 109-129.

Marshall, S. P. (1985). Schemas in problem solving: An integrated model of memory, learning, and instruction. Research proposal submitted to Office of Naval Research.

Mayer, R. E. (1983). Thinking, problem solving, cognition. New York: W. H. Freeman.

Riley, M. S., Greeno, J. G., & Heller, J. I. (1983). Development of children's problem-solving ability in arithmetic. In H. P. Ginsburg (Ed.), The development of mathematical thinking (pp. 153-192). New York: Academic Press.

Webb, N. (1984). Content and context variables in problem tasks. In G. A. Goldin & C. E. Mcclintock (Eds.), Task variables in mathematical problem solving (pp. 69-102). Philadelphia, PA: Franklin Institute Press.

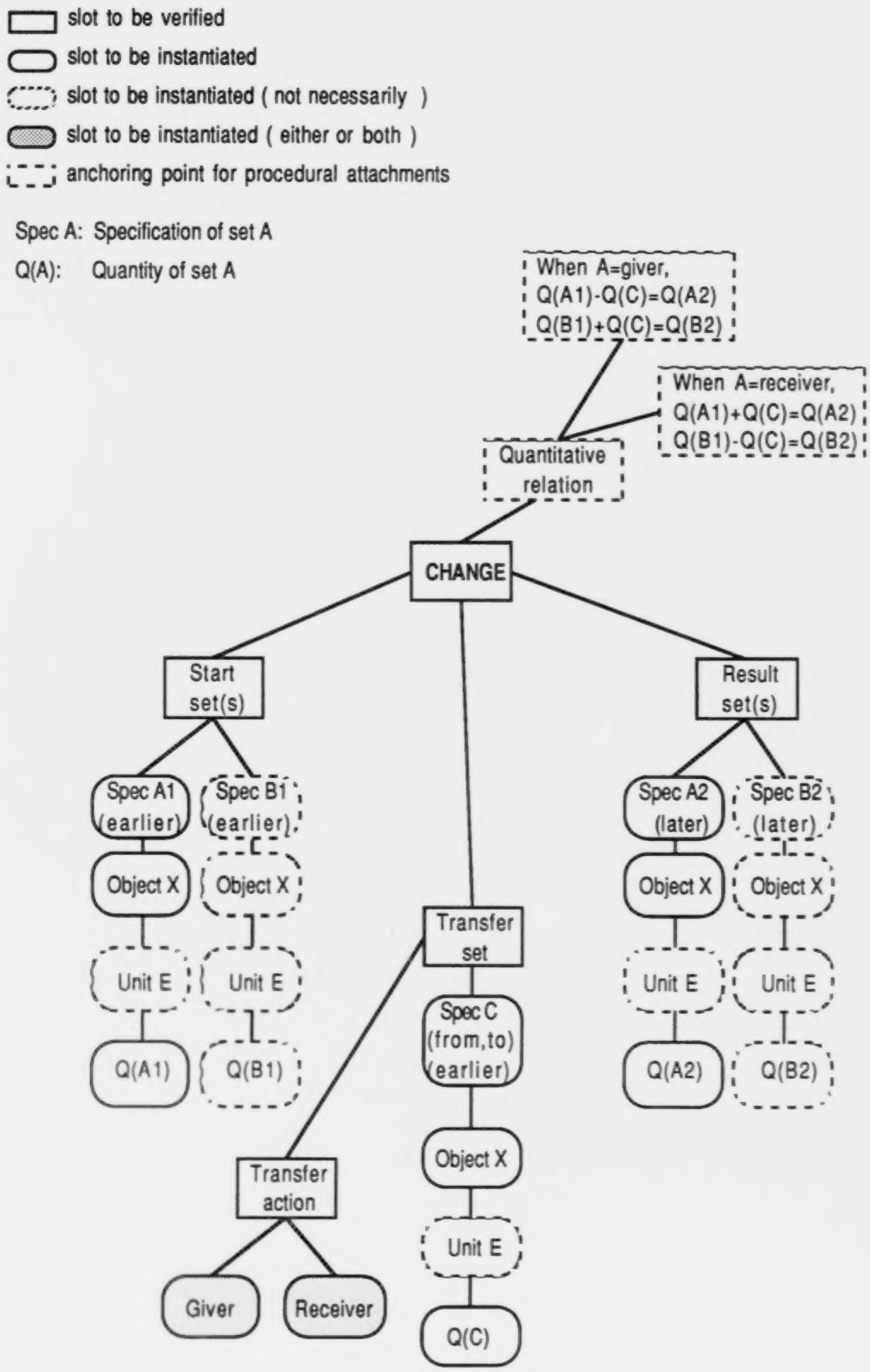
Author Notes

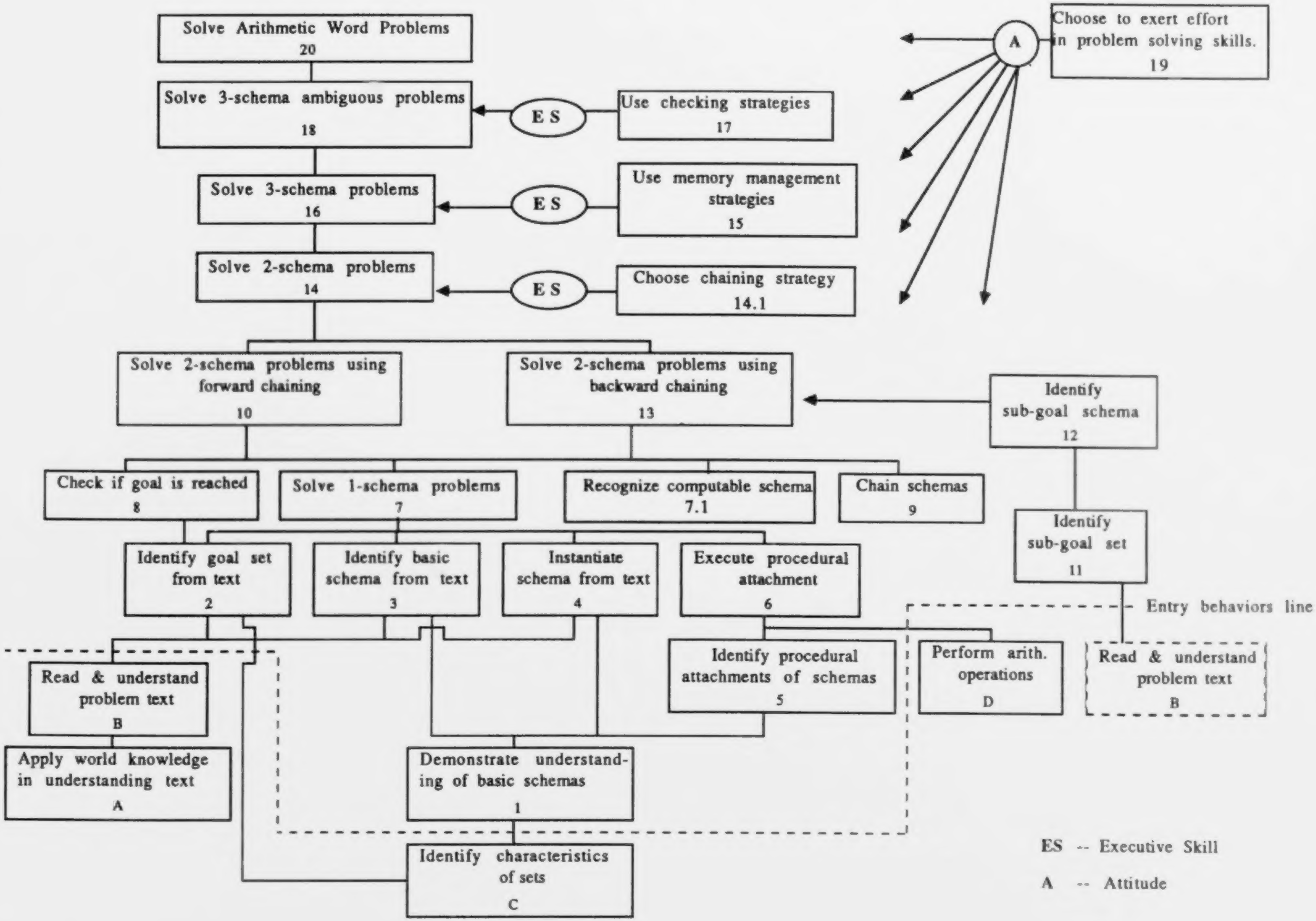
The TAPS project is supported by Grant #IST-8510894 from the National Science Foundation. The ideas expressed herein are those of the authors and do not represent official opinion or policy of the National Science Foundation.

Figure Caption

Figure 1. The Change schema.

Figure 2. TAPS instructional map.


slot to be verified
slot to be instantiated
slot to be instantiated (not necessarily)
slot to be instantiated (either or both)
anchoring point for procedural attachments
Spec A: Specification of set A
Q(A): Quantity of set A
When A=giver, Q(A1)-Q(C)=Q(A2) Q(B1)+Q(C)=Q(B2)
When A=receiver, Q(A1)+Q(C)=Q(A2) Q(B1)-Q(C)=Q(B2)
Quantitative relation
CHANGE
Start set(s)
Result set(s)
Spec A1 (earlier)
Spec B1 (earlier)
Spec A2 (later)
Spec B2 (later)
Object X
Object X
Object X
Object X
Unit E
Unit E
Unit E
Unit E
Q(A1)
Q(B1)
Q(A2)
Q(B2)
Transfer set
Spec C (from,to) (earlier)
Object X
Unit E
Q(C)
Transfer action
Giver
Receiver


Solve Arithmetic Word Problems 20
Solve 3-schema ambiguous problems 18
E S
Use checking strategies 17
Solve 3-schema problems 16
E S
Use memory management strategies 15
Solve 2-schema problems 14
E S
Choose chaining strategy 14.1
A
Choose to exert effort in problem solving skills. 19
Solve 2-schema problems using forward chaining 10
Solve 2-schema problems using backward chaining 13
Identify sub-goal schema 12
Check if goal is reached 8
Solve 1-schema problems 7
Recognize computable schema 7.1
Chain schemas 9
Identify sub-goal set 11
Identify goal set from text 2
Identify basic schema from text 3
Instantiate schema from text 4
Execute procedural attachment 6
Entry behaviors line
Read & understand problem text B
Identify procedural attachments of schemas 5
Perform arith. operations D
Read & understand problem text B
Apply world knowledge in understanding text A
Demonstrate understanding of basic schemas 1
Identify characteristics of sets C
ES -- Executive Skill
A -- Attitude

The Use of Computers in Text Research:
Some Reflections on a Seminar

Paper for AECT annual meeting - 1987

Walter Wager, Professor
Department of Educational Research
Florida State University
Tallahassee, FL 32306-3030

The purpose of this paper is to discuss some of the issues and procedures that developed in a seminar taught by Dr. Robert Gagne and I last spring. The purpose of the seminar was to work with students interested in applying computers to the study of learning from text. There have been numerous studies of text learning, and many different variables have been found to facilitate memory of facts and principles. We wanted to look at these studies and their underlying theories to see what they implied with regard to designing effective computer screen displays.

Why use the computer in text research? The computer is, for the most part, a printed text display medium. The same variables that are manipulated on the printed page, can be manipulated on the computer. Both are capable of presenting words and illustrations and both are capable of presenting questions before, during or after the presentation of text. However, with the computer, presentation is under the control of a program that determines what and when the learner sees next. This is something that is difficult if not impossible with printed text, and researchers have documented the problems of students ignoring or thwarting instructional strategies built into printed texts (R. C. Anderson, 1970).

One problem with using computers as delivery systems in research is the large amount of development time that it takes to create instructional programs. A second problem seems to be a lack of follow-up of research in which they are used. Very often a program is used for only one research study and then it is discarded. In light of the resources spent on programming, the computer doesn't seem to be a very efficient medium for conducting research.

One solution to these problems is to use authoring programs. Authoring programs allow the author to create text and question screens in a relatively straight-forward manner, and the screens can be easily assembled in any number of different sequences for different treatments. Furthermore, since the screens are relatively independent until they are assembled into a lesson, it is easy to modify the screens created for one experiment and use them in another. This feature allows the researcher to build a library of screen displays that could be used by others interested in the same line of research. This facilitates the continuity of research, and allows resources to be used more efficiently. However, one limitation of authoring systems is that they are generally more limited than programs created in a programming language. They often do not offer much flexibility in branching, or in data collection. We found that even with these limitations, the advantages seemed to outweigh the disadvantages.

What variables are associated with text learning?

Prior researchers have manipulated the organization, the level of vocabulary, the size of text, illustrations accompanying the text, advance organizers, cues, objectives, and a number of other variables. Theses effects of these variables were explained by many different theories. R. C. Anderson (1970) postulated that what a student did when confronted with instructional tasks were of crucial importance in determining what the student would learn. To explain the effects of text devices on learning he related them to three stages of learning: attention to the stimulus, encoding the stimulus in a meaningful manner, and conceiving linkages between features of the stimulus that will later serve as cues for retrieval. The implications for the educational technologist are to create displays that ensure that the student will notice the stimulus, translate it into internal speech, evoking images for the things and events named by the words, and conceiving relationships among the imagined things or events.

What is interesting about Anderson's early analysis of devices used to facilitate text learning is that he associates most of them with the process of focusing attention on the stimulus, e.g., the practice of cueing the learner to focus attention on a particular word or phrase by the use of underlining, or the use of embedded questions in text to focus attention on specific content. Few variables were related to the other two processes: encoding the stimulus, and building retrieval cues.

Presently there is considerable interest in schema theory and its implications for the design of textual materials. A schema is considered to be organized knowledge held by the learner, to which new knowledge is related. A basic premise of schema theory is that what a person knows is the major determinant of what he will learn (Anderson, 1984). Schemata theory is not incompatible with the activities previously associated with attention processes, but it seems to focus on variables affecting the second and third processes of learning, namely, cue encoding and associative linkages. However, the devices used by the schema researcher seem to be the same as those previously associated with other learning models, i.e., signals, elaborated stimulus displays, illustrations, embedded questions, etc.

A schema is hypothesized to be accountable for the expectations a learner brings to a learning task. If, for instance, the learner has a good understanding of algebra, a learning task associated with the calculation of the velocity of an accelerating object will be manageable. However, if the student doesn't have an algebra schema, the learning task may be seen as difficult if not impossible. Advance organizers, cues, or embedded questions within the new physics materials will be insufficient to change the situation, short of teaching the student algebra.

On the other hand, possessing a schema may be a necessary but not a sufficient condition for facilitating learning. It is hypothesized that an educational technologist might increase the degree of learning by activating an existing schema possessed by a learner. This activation may be as simple as suggesting an organizing idea or title for the material to be learned (see Bransford and Johnson, 1973), or as complex as deriving an analogy for relating the new material to existing knowledge. But how does activation of a schema differ from recall of prerequisite skills, as proposed by R. M. Gagne (1985)? How does it differ from the "preexisting cognitive structure" described by Ausubel? Furthermore, what if analysis (such as a pretest) determines that the learner doesn't possess the prerequisite skills or preexisting knowledge? Obviously, the concept of schema activation is one that needs better definition and further study.

Another variable associated with schema theory is articulation. All learners possess many schemata, each dependent upon the culture and experiences of that learner. Anderson (1984) believes that the schema exists in degrees of articulation. For instance, most males and many females have what might be called a "football" schema. However, it is likely that the males will have a more articulated schema due to cultural characteristics in which males become more knowledgeable about football. With this in mind, one might find that using terminology associated with football in a math word problem might hinder the ability of the female students to answer the question. For example, "The punter kicked the ball to the 20 yard line, if the field is 100 yards long how far must the team go to get a touchdown?" Obviously, accurately answering this question depends not only on math, but on a football schema as well. What is not so obvious is the fact that the same type of mechanism may be working in standard text materials from which children are expected to learn. Vocabulary that is not a part of the underprivileged child's culture (from which their schema are derived) could be as much a barrier as the football jargon would be to the female students.

I am particularly interested in learning problems of children and the learning handicapped. Schema theory might offer some insights into alternative materials design for the learning handicapped child, maybe because these children seem to have such a problem encoding and retrieving new stimulus materials. Is their impoverished schema to blame? Theorists have speculated that the working memory is capable of holding a relatively few pieces of information at a time. If this information is to be encoded and stored in long term memory it must be attached to existing information possessed by the learner, which must also be pulled into working memory. One might speculate that the total capacity of the working memory of the learning handicapped child is less than that of the normal child, and therefore the amount of new information presented by the environment must be reduced, while at the same time encoding and building associative linkages must be maximized. Can elaborations and cues help to instantiate and tune that schema? These are questions which I hope to address in future research.

The computer seems well suited for the study of many different types of attention devices including cues, questions, and illustrations that can be included where desired within the materials. The computer also seems well suited for the study of variables associated with schema theory. The computer makes it possible to pretest for the degree of articulation of a learner's schema and to branch to different levels of instructional support depending upon the strength of the schema.

Glynn & Britton (1984), Reder (1980) and others have noted that research on the use of text elaboration does not always show the elaborated treatment to be more effective. Glynn & Britton state, "The effect of these devices depends upon whether or not the text actually needs them to be comprehensible." The question facing the designer is, "comprehensible by whom?" While one might agree that educators tend to give too much emphasis to particular elaboration treatments, and not enough thought to the processes supported by these devices. But we do not know much about human information processing, and it is unlikely that we can be very precise in determining where and when specific treatments will and won't be effective.

What directions might text research take? The approach taken in the seminar, was to give the students a number of text passages, from which they could select one to make more memorable. It was obvious that not all the text passages selected were oriented toward the same type of learning outcome. Some were oriented toward information learning, and others toward concepts. It was also obvious that in order to manipulate the text assumptions about the learners (schema) had to be made.

The students were also provided with a reading list (attached) that gave them a start in finding literature related to text learning. The interest of the group seemed to focus on the schema theory, as reflected in the papers in this symposium. Each student chose a theory or proposition of interest to them, and created a CAI presentation to explore the effect of specific text elaborations within the context of that theory. One observation is that the use of the computer often created as many questions as answers with regard to the design of displays. The relatively small text capacity of a computer screen compared to a printed page, the division of the text and necessity for redundancy are variables that are a function of the medium, as much as conscious choice.

With regard to the current state of research on text learning, I feel that it is interesting, but much in need of synthesis. It is likely that schema theory serves to explain one small part of the whole learning process. As a designer I don't feel that the research on schema theory has provided many new guidelines on which to base practice. Perhaps this is due to the complexity of of human behavior. Schema theory research, to date, doesn't give a great deal of consideration to the nature of the text (narrative, expository, argumentation, or descriptive), or the nature of the learning outcomes typically associated with comprehension of these types of text. Educators probably focus more the devices they use in instruction, than they do on the processes served by the devices because we still do not understand these processes very well.

Our experiences in the seminar lead me to encourage other researchers to experiment with the use of the computer as a medium for studying text learning. Authoring programs can relieve much of the drudgery of programming, and open the possibility of creating libraries of materials that can be used by many students. They also give us new perspectives on the application of theory that, perhaps will also help in the clarification of learning processes.

References

Anderson Richard C. (1970). Control of student mediating processes during verbal learning and instruction. Review of Educational Research. 40:#3, Pp. 349-369.

Anderson Richard C. (1984). Some reflections on the acquisition of knowledge. Educational Reseracher, 13:November, Pp.5-10.

Bransford, J.D. and Johnson, M.K. (1973). Consideration of some problems of comprehension. In W. Chase (Ed.) Visual Information Processing. New York: Academic Press, 1973.

Gagne, R.M. (1985). Conditions of Learning, Fourth Edition. New York: Holt Rinehart and Winston.

Glynn, S.M. and Britton, B.K. (1984) Supporting reader's comprehension through effective text design. Educational Technology, October, Pp. 40-43.

Reder, L.M. (1980). The role of elaboration in the comprehension and retention of prose; a critical review. Review of Educational Research, 50:#1, Pp. 5-53.

Reading list given to students in the seminar.

Reading List

Andre, Thomas (1979) Does Answering High Level Questions While Reading Facilitate Productive Learning? *Review of Educational Research*, 49:#2, Pp. 280-318.

Anderson, Richard C. (1984) Some reflections on the acquisition of knowledge. *Educational Researcher*, 13:November, Pp. 5-10.

Anderson, Richard C., Osborn and Tierney. (1984) *Learning to Read in American Schools*. Lawrence Erlbaum Associates (single page summary on schemata).

Frase, L.T. and Swartz, B.J. (1975) Effect of question productions and answering on prose recall. *Journal of Educational Psychology*. 67:#5, Pp. 628-635.

Gagné, R.M. (1984) Learning outcomes and their effects. *American Psychologist*. 39:#4, Pp. 377-385.

Kulhavy, R.W. (1977) Feedback in written instruction. *Review of Educational Research*, 47:#1, Pp. 211-232.

Merrill, Paul F. (1981) Preliminary Guidelines for Employing Graphics in Instruction. *Journal of Instructional Development*, Vol. 4:#4, Pp. 2-9.

Reder, L.M. (1980) The role of elaboration in the comprehension and retention of prose; a critical review. *Review of Educational Research*, 50:#1, Pp. 5-53.

Rothkopf, E.Z. & Kaplan (1972) Exploring the effect of density and specificity of instructional objectives on learning from text. *Journal of Educational Psychology*. 63:#4, Pp. 295-302.

Rumelhart, David E. and Norman, Donald, A. (1978) "Accretion, Tuning and Restructuring: Three modes of Learning". In Cotton J.W. and Klatzky, R.A. (eds.) *Semantic Factors in Cognition*. Erlbaum Associates, Hillsdale, N.J.

Rumelhart, David E. (1980) "Schemata: The building blocks of cognition". From R.J. Spiro, B.C. Bruce & W.F. Brewer (Eds.), *Theoretical Issues in Reading Comprehension*, Erlbaum Assoc., Hillsdale, N.J.

additional researchers you might investigate:

A. Pavio, W.D. Rohwer, H.T. Taba, W. Estes, R.E. Mayer, J.R. Levin

Computers and Instructional Design:

Component Display Theory in Transition

Brent G. Wilson

Dept. of Leadership and Educational Policy Studies
Instructional Technology
Northern Illinois University
DeKalb, Illinois 60115c

March 1987

Computers and Instructional Design:
Component Display Theory in Transition

The field of instruction design (ID) has grown up around computers, programmed instruction, and other forms of "automated" or self-instruction. Most instructional theorists have tried their hand at prescribing or developing computer-based systems (e.g., Gagne, Wager, & Rojas, 1981; Merrill, Schneider, & Fletcher, 1980; Scandura, 1986; Tennyson, 1984). This is because computers provide a highly-controlled environment where manipulation of instructional variables is easily accomplished. The potential for control has led many researchers to suggest that computer-aided instructional (CAI) systems can serve as an "ID laboratory," an environment for testing and validating instructional strategies.

In many ways, CAI serves as a valid microcosm of instructional worlds. All of Gagne's nine events are needed in CAI, just as they are in traditional instructional settings. Principles of learning are just as validly applied to CAI settings as they are to traditional instruction. Presumably, the same laws of nature and instruction are at work in CAI as in traditional instruction. Although some may argue that crucial differences between the environments limit the external validity of CAI research, the fact remains that historically, a healthy interaction has existed between CAI models and instructional design theories of a more generic nature.

In this paper, we examine the relationship between instructional design theory and CAI models. We follow a "case study" sort of method, focusing on component display theory (CDT) as our working example (see Merrill, 1983 for a complete statement of the theory). We intend to show how CDT can be adapted for use with traditional instruction, with automated forms of instruction, and will continue to evolve as CAI becomes more flexible through "intelligent" enhancements.

Building Instructional Theory

In a past edition of the Handbook of Research on Teaching, Snow (1973) talked about theory development in education. An early stage of theorizing is to develop a set of categories and terms for viewing and classifying events within a problem area. This is called taxonomizing, and provides the foundation for any kind of theoretical work. The theorist wants to look at the world in ways that will "cut at the joints;" that is, in ways that will eventually lead to understanding of the phenomenon in question. A later stage in theory development is to connect the categories into relationships, to help researchers explain, predict, understand, or control the phenomenon. Thus the psychologist, having defined various categories of mental disorders, can set about defining determining conditions for those disorders. The physicist can link mass and motion in ways that result in powerful predictions; the pharmacist can determine appropriate blends of drugs designed to remedy complaints.

In the domain of instruction, the problem is more like the pharmacist's than the physicist's. We are interested in developing remedies for problems. Thus the instructional theorist needs to come up with a taxonomy for describing various kinds of learning outcomes, as well as interventions, treatments, and conditions needed to arrive at those outcomes. Simon (1969) called this kind of problem a "science of the artificial" because we are interested in understanding not so much the "natural" world, but more the "artificial" or man-made world of goal-oriented problems and solutions. Instructional theorists are interested in stimulus design as well as response, in structure of interaction as well as structure of cognitive outcomes. That is because, for any instructional problem, it is the design of the intervention that is manipulable. A student's family background may be a given, native intelligence may be a given, yet the nature of the instructional interaction is more under the instructor's control. Seen in this light, instructional research is more like engineering than science. Although lacking the precision of most engineering fields, instructional design has a similar goal-oriented structure. Were it not for the dehumanizing connotation of the term, "instructional engineering" would be an appropriate label for much of what instructional designers try to do.

Component Display Theory: An Instructional Design Theory

Merrill's component display theory is a good example of a taxonomy-based theory. Based on a field of mathematics called "set theory," Merrill defined a taxonomy of content types, including facts, concepts, procedures, and principles. Facts combined concepts in arbitrary associations; concepts were basic building-block categories defined by critical attributes; procedures were sequential steps of operations performed by a person to reach a goal; principles were cause-effect or logical relations between concepts for the purpose of explaining or predicting.

Facts can only be remembered and cannot be generalized; however, the other content elements can be taught at two levels of outcome: the remember level, in which the learner recalls the definition or statement of the content's meaning, and the "use" level, in which the learner must show mastery by applying the concept, procedure, or principle to new cases. Combining the content types with the performance level results in the basic taxonomy of cognitive learning outcomes, shown in matrix form in Figure 1.

With the goals or learning outcomes defined by the performance/content matrix, Merrill's next task was to develop a language for talking about instructional presentations (the "display" in componant display theory). He differentiated between "primary" and "secondary" presentation forms. Primary presentation forms were the basic presentations of definitions,

LEVEL OF PERFORMANCE				
USE	(Fact are not traditionally applied or used	-Is this film clip in the film noir style? -Which of these instances is a concept? -Look at the map below. Is the body of water a bay or a strait?	-Start up an IBM PC. -Dub a videotape. -Process this travel request form.	-Using Gagne's 9 events, evaluate this lesson. -Apply the commutative property to the following equation. -Can you tell by looking at this document what print specifications I need to fix it?
REMEMBER	-Who is the president of U.S.? -What is the value of pi? -The symbol for helium is ______?	-What distinguishes film noir? -What is the definition of a concept? -What is the difference between a bay and a strait?	-What are the steps for starting an IBM PC? -Define the procedure for dubbing a videotape. -Tell me how to process this travel request form.	-State Gagne's 9 events of instruction? -Define the commutative rule in algebra. -Describe the inputs and outputs of the print formatting process.
	FACTS Arbitrary associations between things.	CONCEPTS Categories of things sharing attributes in common.	PROCEDURES Sequence of steps performed to reach a goal.	PRINCIPLES Cause-effect, logical, or process relationships between 2 or more concepts.

KINDS OF CONTENT

Figure 1. Component Display Theory's performance/content matrix, a taxonomy of cognitive learning outcomes.

examples, and practice cases with feedback, shown in Figure 2. A display could present the general statement of the concept, procedure, or principle, or an instantiation of the content. Further, the display could present the content in "expository" or "telling" fashion, or ask the student to respond to a practice case ("inquisitory" mode).

In support of these primary presentation forms, secondary presentation forms included "help" displays, elaboration displays, analogies, advance organizers, "advice" displays, and many others. Merrill and colleagues worked out a comprehensive taxonomy of display types, including algorithmic and heuristic re-statements of the content definition (see Figure 3).

Learning outcomes and presentation displays were then linked together by a set of rules. Adequacy rules referred to general techniques that could be applied across content types; for example, highlight critical or important information. Consistency rules specified different combinations of displays, depending on the targeted learning outcome, borrowing Gagne's "conditions-of-learning" approach. Examples of each are given in Figure 4.

In comparison to most educational models, CDT was highly formalized, tying technically-named elements together with explicit rules and procedures. The formal nature of the theory might put off a classroom teacher, but its explicitness and precision found a more comfortable home in computer-aided instruction. The TICCIT system, a minicomputer-based CAI system developed at Brigham Young University and the University of Texas, relied heavily on CDT constructs. The system was primarily designed by Bunderson (1973) and Merrill (1974), and is presently implemented by Hazeltine Corporation of Alexandria, Virginia. The TICCIT system adhered closely to a CDT-style model. TICCIT's authoring language incorporated CDT terms and strategies; the keyboard was customized to include keys for "RULE", "EXAMPLE", "PRACTICE", "EASY", "HARD", "HELP", and other theory-based options; content experts were asked to write their lessons within the CDT model.

The sequencing of instructional components within TICCIT (and within CDT) was largely determined by learner control. In a controversial paper, Merrill (1975) suggested that instructional designers might best individualize instruction by letting the learner decide which instructional strategies are needed in a given situation. If a learner feels a need for an example, an example may be only a keypress away. Learner control of instructional components was meant to circumvent the complex problems inherent in trying to adapt instruction to individual differences, a problem which continues today.

CDT brought a measure of precision and discipline to instruction, particularly CAI and programmed instruction. CDT generated a great deal of research, mostly confirming the value of its constructs. An extensive evaluation of TICCIT was shown to

GENERALITY LEVEL		TELLING (no overt reponse)	ASKING (overt response required)
	GENERAL	Present definition, rule statement, or other representation of the content generality.	Present example, non-example, or illustrating case.
	SPECIFIC	Ask for definition, rule statement, or paraphrase of the generality.	Present new problem, ask learner to apply the generality to the problem.

STUDENT PERFORMANCE MODE

Figure 2. Four kinds of primary presentation forms.

PRESENTATION	EXAMPLE
Context	Story, vignette, historical background to heighten interest and meaningfulness of content
Prerequisite	Explanation of concepts used in the definition or example that the learner may not know.
Mnemonic	External aid or device to help learner remember content. Could be a picture, verbal imagery, or phrase to help recall of verbal chains.
Mathemagenic elaboration (help)	Cues that guide learner toward important content features--typographical devices, highlighting, underlying, use of space, boxes, adjunct questions, etc.
Alternative representation	Restatement of generality using diagrams, charts, formulas, or simplified vocabulary.

Figure 3. Kinds of secondary presentation forms (for a more complete discussion, see Merrill, 1983).

CONSISTENCY RULES

To teach a concept, procedure, or principle at the use level, present:

- A definition
- 2 or more expository examples
- 2 or more new practice cases with feedback

To teach a learner to paraphrase the definition of a concept, procedure, or principle, present:

- A definition
- An example
- A practice item requiring definition paraphrase

To teach remember a specific case verbatim, present:

- The case
- A practice item asking recall of the case

ADEQUACY RULES (Displays added to those specified by consistency rules)

To teach a concept, procedure, or principle at the use level, present:

- Mathemagenic elaboration (help) with the definition
- Prerequisite elaboration
- An alternative representation of the definition
- Examples with help and alternative representations available
- New practice cases with alternative representations of the definition available, feedback with attention-focusing cues

To teach a learner to paraphrase a definition, present:

- A definition with a mnemonic
- An example with help or attention-focusing information
- Give correct-answer feedback with help or attention-focusing information

To teach a learner to remember a specific case verbatim, present:

- correct-answer feedback

Figure 4. Illustrative adequacy and consistency rules for presenting displays to achieve cognitive learning outcomes.

increase student achievement over traditional instructor-led university courses.

Before we bring CDT up to the present, we will digress to review two basic approaches to instructional design: the analytic and the holistic methods. Understanding differences between these two methods will have some bearing on our discussion of CDT and the remainder of the paper.

Analytic vs. Holistic Methods of Instructional Design

Because education is such a complex problem-solving activity, there is room for more than one approach to doing it. Joyce & Weil (1985) have documented a number of different models of teaching, reflecting a variety of philosophical positions. The two methods described in this section are actually more "paradigms" in the Kuhnian sense of the word, describing general mind-sets and assumptions concerning the way we see things and the way we do our jobs. The descriptions are simplified types of very real differences in methodology, and are not meant to caricature either approach.

The analytic method suggests the following basic procedure in designing solutions to instructional problems and goals:

1. Break down the instruction (or the instructional problem) into its parts.

2. Assemble the parts into a teaching sequence or instructional solution, proceeding from simple to complex, from sub-skill to sub-skill, until the instructional goal is obtained.

Examples of the analytic method applied to education include the ISD model, Gagne's taxonomy of learning outcomes and conditions-of-learning approach, Gagne's learning hierarchy analysis, criterion-based measurement models, and Gilbert's performance audit. Merrill's component display theory also can be seen as an example of the analytic method.

The holistic method is somewhat harder to define for this author, an observation probably attributable to the author's background and training. A holistic method seems to follows this basic procedure:

1. Simplify the work environment until you find a task the learner can become meaningfully engaged, and with work satisfaction.

2. Develop a series of work environments in stages, allowing the learner to progress until full mastery is attained.

Examples include the mentoring relationship, the apprentice/master model, the craftsman model, and Bunderson's notion of "work models" (Bunderson, Gibbons, Olsen, & Kearsley, 1981). Holistic models of evaluation and testing are other examples. Reigeluth's elaboration theory (Reigeluth, Merrill, Wilson, & Spiller, 1980) seems to be a hybrid, making use of goals and techniques from both approaches.

The key difference between the two methods is reliance on analysis as a method of developing appropriate task environments. The analytic method specifies tasks and instructional strategies based on breakdown and re-assembly of parts; once broken down, the instructional designer "understands" the task and can re-assemble the task into a proper instructional lesson. Students systematically learn the parts, sub-skills and sub-knowledge, combining them in greater performance requirements until the whole task is mastered. The holistic method, on the other hand, takes the whole task and cuts back without a full analysis. The cutting back may be based on intuition, from common sense, or from a master's own memories of having learned the material. The instructor does not try to analyze or document the full task performance; rather she develops work environments where a valuable subset of the master's skills and knowledge can be put to good use. A series of progressing environments is what constitutes the "journey" of instruction from novice to master. The holistic method is strong on synthesis rather than analysis.

Consider the example of foreign language learning. Not long ago, the fad in language learning was the "language lab," a facility equipped with tape recorders, head-phones, and individual booths. The activity of the language lab was drill & practice--hear a sound (a word, phrase, or sentence), repeat the sound; hear a sound, respond to the sound. Theorists following the analytic method hypothesized that if learners could master the fundamental parts of the language--"automatize" them if you will--that they could build their understanding incrementally until they approached mastery.

Currently, there are scores of language labs that remain under-used. The labs failed to fulfil their expected potential; students somehow did not synthesize the bulk quantities of new knowledge they were acquiring. Theorists turned their attention toward a more holistic goal termed "communicative competence." The new emphasis is on total communication, with a corresponding deemphasis on correct syntax, structure, and vocabulary. Students stand when they say "stand," they say "water" when they get a drink. They engage in goal-based dialogues with classmates and teacher. The emphasis is on communication, however the student can manage it. Details of grammar and language structure are introduced at a later stage.

The two methods described above have their own sets of advantages and risks. The analytic method can be reliable, efficient, and useful for managing large-scale training projects. At the same time, because the analytic method builds solutions based on a breakdown of a problem, there is a tendency to focus on trivial but well-understood aspects of the problem. Chronically neglected aspects of "analyzed" instruction include attitudes, self-concept, creativity, higher-order problem solving and cognitive strategies. Similarly, at its best the holistic method can result in rich and satisfying experiences, leaving an enduring impression on the learner. Or, holistic instruction can be wasteful, misdirected, shallow, and inefficient (see Wilson, 1987). Understanding the relative strengths of the two methods can help the instructional designer who wants to be sensitive to a full range of methodologies and outcomes.

Display Assumption of CDT

From the outset of CDT's development, Merrill acknowledged an important assumption underlying the theory:

> Content can be broken down into discrete chunks or displays of instruction, and these displays can be classified and combined into suitable instructional presentations and strategies.

This assumption, virtually a restatement of the analytic method, posed no threatening constraints, and did not detract from the theory's usefulness. Indeed, the display assumption was ideally suited to basic forms of self-instruction. Teachers have traditionally been wary of instructional-design approaches, yet core ideas of component display theory have been successfully taught to classroom teachers and trainers. Subject experts are often enthusiastic about CDT because it gives them a shared vocabulary with instructional designers and a structure for approaching content analysis. Over the years the popularity of CDT among instructional designers has increased, largely because of its appealing use of content types and instructional-strategy "templates." The display assumption seems not to have hurt the theory's application to traditional instructional forms.

Merrill originally developed CDT at a time when the world of CAI was based on screen displays, called "frames" after the programmed instruction term for a chunk of instruction. Frame-based CAI follows this basic approach:

1. Script/develop screens of content, practice, etc.

2. Combine those screens into sequences of instruction, using branching, loops, and other adaptive strategies.

Today, most CAI continues to be frame-based; almost all authoring systems on the market follow a frame-based approach.

The frame-based orientation to CAI is being challenged presently by a group of long-standing critics. Generative forms of CAI utilizing artificial-intelligence methods are exerting considerable influence among CAI theorists (including Merrill and Bunderson). Intelligent computer-aided instruction (ICAI) moves instruction away from a display or frame orientation, and toward a knowledge-base orientation (Kearsley, 1987). Specifically, CAI programs explicitly try to:

- o model the content needed for mastery
- o model the current content understanding of the student
- o model the strategies of an effective tutor
- o control instruction by linking the tutoring strategies with the master's and student's knowledge states.

The modeling of strategies and knowledge states is accomplished by expert systems technology: IF-THEN rules are combined to form knowledge bases, which in turn are accessed by reasoning modules using logical inferencing strategies (Wilson & Welsh, 1986).

ICAI developers have made strides in representing content, and in modeling learner states. Where they have fallen short, in the author's opinion, is in modeling the strategies of an effective tutor. Admirable work has been done by Collins and colleagues in modeling "discovery" tutorial methods (e.g., Collins & Stevens, 1983), but their methods apply best to content already familiar to the learner. Engaging in a mixed-initiative dialogue with the computer, the learner explores and analyzes the familiar content to arrive at new conclusions and insights.

Merrill's language for talking about instruction may still be a useful mechanism, even for ICAI applications. Whereas the display assumption was once thought to refer to individual screens, the presentation chunks of "example," "practice," "analogy," "help," "advice," and so on, may also be seen as strategy chunks called up by an expert system governing instructional interactions. CDT seems to offer an excellent starting point for intelligent tutoring strategies by providing a set of correspondence rules relating specific units of instructional strategy to a range of cognitive learning objectives. If so, CDT will continue to evolve and be adapted as delivery systems grow in power and flexibility.

We made the distinction above between analytic and holistic methods of instructional design. CDT clearly fits primarily within the analytic tradition. As it is applied to ICAI development projects, however, CDT may assume more features of the holistic method. Once a knowledge base of content and instructional strategies is developed (an admittedly analytic task), the computer will be able to assist in developing work environments for the learner to meaningfully engage in complex performances. Artificial intelligence technology, particularly expert systems and natural language interfaces, can do much toward implementing Bunderson's notion of progressive stages of work models leading to mastery. The work models will have an analytic foundation, but will be able to provide many of the desirable features of the holistic method of design.

Conclusion

We have traced the application of component display theory through its roots in programmed instruction and computer-aided instruction, through traditional forms of education, and finally to its seeming potential for ICAI modeling of tutoring strategies. In each case, the concepts of CDT are applied differently: in CAI, learner control is a central feature; in traditional training and education, learner control is usually constrained by media and system forces; with ICAI, the "display assumption" shifts from discrete screen displays toward the notion of small chunks of instruction, governed by a knowledge base of tutorial rules. ICAI's ability to engage in mixed-initiative dialogue can minimize some of the problems encountered by TICCIT's radical use of learner control.

In the 1970's, Gagne objected to the notion of "content analysis," arguing that a "task" level was all that was needed--content by itself wasn't really "there" (Gagne, 1974; Gagne, 1976). Ironically, CDT's content analysis features seem to strongly appeal to instructional designers and subject experts. Moreover, the content analysis features fit easily within ICAI, one of whose major goals is to represent content through explicit logical relationships. Because much of the instructional designer's task is to represent knowledge adequately, the technologies of CDT and ICAI will probably have a lot of learn from each other.

Instructional design theory and CAI theory will continue to interact and influence each other; however, as ICAI methods continue to preoccupy the attention of CAI theorists, an increasing gap will likely develop between state-of-the-art CAI theory and general ID practice. The traditional trainer/educator will not get much out of a research symposium on ICAI methods and theory. The differences between CAI and ID practice evident in the 1970's and 80's will become more apparent in the 1990's. This makes the role of theories like CDT that can span across delivery systems all the more important, because they can link knowledge gains in one area to the other.

Component display theory is not the only promising theory that spans across CAI and ID theories. As mentioned, models of Gagne, Scandura, Landa, Lepper, to mention a few, are relevant to a variety of delivery systems. We hope that as interest continues in CAI and ICAI, a continuing relationship will be developed linking general models of instructional design to media-specific applications.

References

Bunderson, C. V. (1973). The TICCIT project: Design strategy for educational innovation: Proceedings of the educational technology symposium. Institute for Computer Users in Education (ICUE) Technical Report No. 4. Provo, UT: Brigham Young University.

Bunderson, C. V., Gibbons, A. S., Olsen, J. B., & Kearsley, G. P. (1981). Work models: Beyond instructional objectives. Instructional Science, 10, 205-215.

Collins, A., & Stevens, A. L. (1983). A cognitive theory theory of inquiry teaching. In C. M. Reigeluth (Ed.), Instructional-design theories and models: An overview of their current status. Hillsdale, NJ: Erlbaum.

Gagne, R. M. (1974). Task analysis--its relation to content analysis. Educational Psychologist, 11(1), 11-18.

Gagne, R. M. (1976). The content analysis of subject-matter: A dialogue between Robert M. Gagne and M. David Merrill. Instructional Science, 5, 1-28.

Gagne, R. M., Wager, W. W., & Rojas, A. (1981, September). Planning and authoring computer-assisted instruction lessons. Educational Technology, 17-21.

Joyce, B., & Weil, M. (1985). Models of teaching (3rd ed.). Englewood Cliffs, NJ: Prentice-Hall.

Kearsley, G. P. (Ed.). (1987). Artificial intelligence and instruction. Reading, MA: Addison-Wesley, in press.

Merrill, M. D. (1974). Premises, propositions, and research underlying the design of a learner controlled computer assisted instruction system: A summary for the TICCIT system. Working paper No. 44, Division of Instructional Services. Provo, UT: Brigham Young University.

Merrill, M. D. (1975). Learner control: Beyond aptitude-treatment interactions. AV/Communication Review, 23, 217-226.

Merrill, M. D. (1983). Component display theory. In C. M. Reigeluth (Ed.), Instructional-design theories and models: An overview of their current status. Hillsdale, NJ: Erlbaum.

Merrill, M. D., & Boutwell, R. C. (1973). Instructional development: Methodology and research. In F. N. Kerlinger (Ed.), Review of research in education, vol. 1. Itasca, IL: Peacock.

Merrill, M. D., Schneider, E. W., & Fletcher, K. A. (1980). TICCIT. Englewood Cliffs, NJ: Educational Technology

Publications.

Reigeluth, C. M., Merrill, M. D., Wilson, B. G., & Spiller, R. T. (1980). The elaboration theory of instruction: A model for sequencing and synthesizing instruction. *Instructional Science*, *9*, 195-219.

Scandura, J. (1986, April). *Intelligent rule-based instructional systems*. Paper presented at the meeting of the American Educational Research Association, San Francisco.

Simon, H. A. (1969). *The sciences of the artificial*. Cambridge, MA: MIT Press.

Snow, R. E. (1973). Theory construction for research on teaching. In R. M. Travers (Ed.), *Second handbook of research on teaching.* Chicago: Rand McNally.

Tennyson, R. (1984). Artificial intelligence methods in computer-based instructional design. *Journal of Instructional Development*, *7*(3), 17-22.

Wilson, B. G. (1987). Applying hard and soft technologies to weaknesses in traditional instruction: Possible progress and some unintended side effects. *Educational Technology*, in press.

Wilson, B. G., & Welsh, J. R. (1986, November). Small knowledge-based systems in education and training: something new under the sun. *Educational Technology*, 7-13.

Author Notes

Requests for reprints should be sent to Brent Wilson, Northern Illinois University, GA 219--LEPS, DeKalb, IL 60115.

Real-Time Graphics for CAI: A Rudimentary Grammar and Demonstration Program.

Bill Winn

University of Washington.

INTRODUCTION

The ideas presented in this paper began with the realization that in intelligent computer-assisted instruction (ICAI) systems it is possible to make decisions about instructional strategies while instruction is underway. Instructional design has evolved in a context where the selection of instructional strategies is separated in time from their implementation (Richie, 1986; Winn, 1986a). This has caused a number of difficulties (Nunan, 1983) concerned primarily with the ability of the designer to predict what will occur once instruction has started. If instructional design is concerned with making decisions based in part upon the conditions that prevail when instruction takes place (Reigeluth, 1983), and if as is usually the case those conditions change as a result of instruction occurring, then the difficulty of the designer's task becomes apparent.

There are two alternatives towards which the designer might strive in order to avoid this difficulty (Winn, in press). The first is the creation of a complete and predictively valid theory of instruction that is capable of predicting with considerable accuracy all of the contingencies that might arise during instruction. Instructional theory is at present a long way away from this ideal. The second alternative is to endow the instructional systems through which instruction is implemented with sufficient "expertise" to deal with problems on the spot in much the same way as an expert teacher can (see Berliner, 1986; Schon, 1983). This is presently the more realistic alternative because ways in which artificial intelligence can be brought to bear upon instructional problems are being developed (Sleeman and Brown, 1982).

An important aspect of building expertise in instructional decision-making into ICAI systems has to do with the ways in which information is presented on the screen. Granted, information presentation is only one part of instruction. (Gagne and Briggs [1979] list nine "events" that should occur during instruction, of which presenting information is only one). However, the need for the system to contain a large pool of potentially useful methods for selection through the application of prescriptive instructional principles requires that the system also be capable of presenting information in a variety of textual and graphic formats. This is because different learning tasks for learners of different abilities and styles optimally require information to be presented in formats that match those tasks and abilities. The body of literature into individual differences in ability to learn different tasks from different presentation formats is well known. Also well known is the fact that one-on-one tutoring, of the kind that ICAI can provide, leads to remarkable gains in achievement when compared to more traditional modes of instruciton (Bloom, 1984). Successful tutoring requires that information be presented in consideration of students' individual differences in information processing.

Students typically interact with computers through interfaces built around language. This is probably because the development of artificial intelligence has been closely coupled to research into a number of aspects of language, such as semantics, syntax, how information is stored in memory, and how comprehensible utterances are produced (Norman and Rumelhart, 1975; Schank, 1984; Schank and Abelson, 1977). As a result, the capability of intelligent systems to present information in graphics has been less well developed (Christopher, 1985), with some notable exceptions, such as STEAMER (Hollan, Hutchins and Weitzman, 1984), which is an expert system, using intelligent graphics, that teaches about steam power plants in ships.

The focus of this paper is on graphics and how they can be created, in real time, from information stored in a database. This is a special case of the general trend towards endowing instructional systems with a degree of decision-making, or design, expertise. It requires that the system not only present information in a variety of graphic formats to satisfy the requirements of a large repertoire of instructional strategies, but also that the system decide upon the format in which information is to be presented during instruction. This would provide the equivalent of a teacher drawing a chart or diagram on the blackboard on the spur of the moment in order to clarify a particular point or elaborate upon a particular concept.

The term "graphics" is used in this paper to refer to illustrations whose purpose is to make abstract ideas more concrete through the use of spatial analogy. These illustrations stand in contrast to pictorial illustrations whose purpose is often to make very concrete ideas more abstract (see Dwyer, 1978; Winn, 1986b). Operationally, this means that the paper is talking primarily about diagrams and charts, although allusion will be made to graphs as well as the need arises.

A MODEL FOR ICAI

Figure 1 illustrates a generalized model of the way an ICAI system might be constructed. It has the following characteristics:

===================
Figure 1 about here
===================

1. Information it "knows about" is stored in a database in an abstract form, such as a semantic network. The criterion is that the propositions in the database must be capable of expression in any of a number of textual or graphic formats, hence the need for them to be expressed in abstract form.
2. The student interacts with the database through a two-way interface consisting of a number of parts. For input, the interface consists of a parser that determines whether the student's input is something that the system can recognize, and a set of diagnostic routines that determine what it is the student needs to know and how the student can best be serviced. The output side of the interface takes information derived from decisions made by a set of decision rules and converts that information into screen displays.
3. The heart of the system is a collection of rules that operate in accordance with a number of factors. The first of these consists of the instructional conditions that currently prevail, such as what the student has already learned, the student's mental model of the material to be mastered and how correct it is (see Anderson, Boyle and Yost, 1983; Larkin, 1985), the student's abilities and learning styles. Second is the information that has to be presented, that has been retrieved from the database. And third is the syntax of the forms in which information is to be presented. Thus, the decision rules can be exemplified in the following:

> Given that the student has already learned what a mammal is and is a poor verbal learner; (conditions)
> And that the information to be presented is contained in the proposition "whale ISA mammal"; (information)
> And that, in diagrams, superordinate concepts are placed above subordinate concepts; (syntax)
> Then place "mammal" above "whale" and join it to "whale" with a vertical line labelled to indicate class membership (strategy).

Rules such as these clearly draw upon theory in a number of different areas. Obviously, instructional theory containing prescriptive principles involving instructional conditions, outcomes and methods (Reigeluth, 1983), is involved. In addition, there are syntactic rules that specify the relative placement on the screen of subordinate and superordinate concepts. And there are semantic rules that map the information from the database onto the structures specified by the syntax. In other words, there is sufficient information in the proposition "whale ISA mammal" for the system to determine which concept is subordinate to which. In order to examine the way in which these two latter types of rules operate, it is useful to shift our context to a linguistic one for the moment, and look at what a "grammar" of graphics might involve.

GRAMMAR

Figure 2 represents the same general model for ICAI but as a linguist might conceive of it. A number of features of the model remain unchanged. But the decision rules are now thought of as a "grammar" which, as grammars do, has three components to it: a syntactic component, a semantic component and a pragmatic component. (See Salomon, 1979, for a discussion of syntactic and semantic aspects of symbol systems and Kosslyn et. al., 1983, for an elaboration of how these three components function in relation to the meaning of graphs). Each of these will now be examined.

Syntax.

A syntax can be thought of as a set of rules that permit the creation of all the acceptable structures, and only acceptable structures, that the utterances of a language can have. Syntactic structures are content-independent, and thus syntax is considered to be separate from semantics (Chomsky, 1962, 1965; Fowler, 1971). Theories of syntax are derived from the study of syntax of language. While it may not be legitimate to draw parallels between language and graphics for all aspects of grammar, we take the construct of syntax, as developed for language, as the basic paradigm, and diverge from it where necessary.

Structure. The syntactic structure of graphics consists of two types of fundamental component which may behave in certain ways and which are governed by sets of rules analogous to phrase structure rules. The two components are "elements" and "relationships", (see Knowlton, 1966; Szlichsinski, 1980; Schlichtmann, 1980 among others for a more detailed exploration of this idea).

Elements consist of concepts or clusters of concepts. "Concept" is used here in the same sense as it is used by Norman and Rumelhart (1975, pp. 40-44) when describing active semantic networks. Concepts are what propositions make statements about and between which predicates describe relationships. In a tree diagram of animals, the labels "cat", "elephant", "mammal", "vertebrate", referring to these particular concepts, would correspond to "elements" in the syntax.

Relationships describe how concepts are connected. They correspond to predicates in semantic networks. In any syntactic system, they are finite and usually small in number, while the number of concepts and thus the number of potential utterances is in theory unlimited. In the tree diagram of animals, relationships between pairs of concepts would represent predicates indicating class membership (cat ISA mammal), the attribution of qualities (elephant IS big), of characteristics (elephant HAS trunk), and so on.

Elements and relationships can be thought of as variables, or placeholders, that are instantiated when the semantic component is added to a structure. In this sense, structures can be thought of as abstract schemata that are used for the interpretation of information (Anderson 1977; Neisser, 1976; Thorndyke & Hayes-Roth, 1979). However, when we keep the syntactic component separate from the semantic component, all we can do is identify the dimensions along which the elements and relationships can vary.

Elements can vary along two dimensions, notationality and dominance.

1. Notationality (Goodman, 1968; Salomon, 1979) refers to the symbol systems that are used when an element is represented in a graphic. In notational systems, each symbol is discrete and separable from others. In a non-notational system, this is not the case. Where one symbol begins and another ends is not easily determined. Thus, in the animal hierarchy, the concepts could be represented notationally as labels or non-notationally as pictures. A critical correlate of notationality is "repleteness". This alludes to how many dimensions in the representation of a message are meaningful. In a color photograph, size, color, shape, form, placement, contrast, etc., all carry meaning. In a flow diagram only position of the elements on the page and the arrows might be meaningful. The thickness of the lines, whether they are colored or not and even whether the elements are shown as pictures or labels might not be relevant. Salomon (1979) goes into this in much more detail.

2. Dominance refers to those characteristics of the way in which an element is represented that make it more or less dominant to the human perceptual system. Thus, the size with which elements are represented, and the way they are made to stand in contrast to other elements by color cueing, different styles of type, and so on, affect dominance.

Relationships can vary along three dimensions, proximity, placement, and type of link. Placement itself involves a number of additional dimensions.

1. Proximity refers to how close one element is to another on the page or screen. As the proximity among groups of elements varies, they form more or less distinct clusters of elements. It should be noted that well-defined clusters of elements can function in the same way as single elements in a structure, thus enabling the formation of hierarchies and subsets of elements.

2. Placement can refer to the placement of elements relative to the frame (screen or page boundaries) or to each other. These two dimensions are referred to as absolute and relative placement respectively.

i. Absolute placement is concerned with whether an element is at the top, bottom, left or right or middle of the frame.

ii. In the case of relative placement, an element can be above, below, to the left or right of another, or can be completely or partly enclosed within another. The former is illustrated when the word "mammal" is placed above "cat" to indicate class membership, the latter when "cat" is included with "dog" and other labels within a circle labelled "mammal".

3. Links. The links among elements may be inferred from proximity and placement, or they may be made explicit by means of a number of devices. These include representations of predicates, such as the label "belongs to" or "has", lines, arrows, and combinations of these. The notationality and the repleteness of the links can

vary in ways that were discussed above for elements for elements.

Syntactic Rules.

Syntactic structures for graphics are derived from rules that specify how the components of a structure may vary along the dimensions we have just described. (If a structure is considered to be analogous to a sentence, then these rules operate in the same way as phrase structure rules in transformational grammar. For example, NP -> Art + N is a legal rule, while NP -> N + Art is not, at least for English). Some of the syntactic rules of graphics are:

1. Elements that are causes of or antecedent to other elements are placed to their left and/or joined to them by arrows pointing to the effect or object.
2. Elements representing superordinate or inclusive classes are placed above elements representing subordinate or included concepts.
3. Subordinate or included concepts are placed inside elements representing superordinate classes (e.g. set and Venn diagrams).
4. Qualities and attributes of a concept are "attached to" the element that represents it. If the element is represented using a non-notational symbol system, the qualities and attributes may be represented as pictures. If a notational system is used, the attachment of qualities and attributes may be achieved by placing labels describing them close to the element, or by including them in the same box or circle that encloses the label for the element.
5. Elements that are more important than others should be made dominant.
6. Elements representing concepts that are conceptually related should be placed close together.

Psychological Validity.

It should be noted that a number of these rules appear to be statements of the obvious. The reason for this is that any syntax is first and foremost descriptive of usage rather than prescriptive. Some of the rules are therefore derived from the conventions of a particular usage of graphics for communication that is often culturally based. For example, rule one requiring that causes be placed to the left of their effects describes common usage in those cultures where language is written from left to right across the page. Other rules have validity on the basis of psychological research and theory.

Kosslyn et al. (1983) remind us that the Gestalt psychologists (Wertheimer, 1938) developed a number of rules pertaining to the ways in which elements are placed and linked in a display may be meaningfully linked. (Fleming and Levie, 1978, also describe a number of these rules as "principles" of message design). Wertheimer's (1938) laws include: Proximity, which states that elements placed close together tend to be associated; Similarity, stating that elements that look alike tend to be associated; Symmetry, which tends to impose figural cohesion onto collections of elements; Good continuation, which claims that when elements form good figures in their aggregate they will be seen as belonging together; Common fate, which ascribes a similar quality to apparently moving elements that have a common trajectory; Good figure, in which elements having a closed boundary are more likely to be seen as wholes than figures lacking this feature.

In addition to Gestalt principles, other psychological studies of graphics and how people process the information they contain have have confirmed the validity of our rules of graphic syntax. Winn (1982, 1983) has shown that elements in flow diagrams tend to be processed from left to right and top to bottom, suggesting that antecedents should be placed to the left of causes and superordinate categories above subordinate ones. Rabinowitz and Mandler (1983) found that simply placing collections of words to be learned serially in physical groups on a page improved subjects' ability to remember them. In a summary of a number of studies, Hartley (in press) has reported that the way in which text is placed on the page affects the way it is interpreted. And a number of researchers (Holliday, Brunner and Donais, 1977; Koran and Koran, 1980; Winn and Holliday, 1982) have reported that flow diagrams complying with various of the syntactic rules described above have made it easier for students to learn material.

Semantics.

The semantic component of the grammar is concerned with the way in which information is made meaningful by mapping it onto a structure. It is assumed that the information is contained in propositions in a database of some sort, and that these propositions contain information as concepts and predicates that can be mapped onto a structure. The semantic rules of the system must achieve several purposes.

1. They must link specific predicates with specific syntactic rules. That is to say, they must lead to the identification of the predicate ISA with subordination, and with the syntactic rule that requires subordinates to be placed below superordinates. Or they must associate CAUSE with cause-effect relationships and the rule that places causes to the the left of effects.

2. They must be able to associate different concepts with the appropriate placeholders in the structure. For instance, "mammal" must be identified as the concept that is superordinate to "cat" in the proposition "cat ISA mammal". In the same way, "lightning" must be identified as the cause in the proposition "lightning CAUSE fire".

3. They must be able to determine which concepts from the database are conceptually "close", and thus to identify clusters of concepts. Therefore, they must be able to determine how many concepts or "nodes" in the network occur between any two concepts. If "cat" and "elephant" have only one node between them, "mammal", and "snake" and "lizard" have only one, "reptile", between them, with "mammal" and "reptile" being linked by an additional node, "animal", then "cat" and "elephant" are closer to each other than to the two concepts in the "reptile" category and form a cluster.

4. They must be able to determine which concepts are dominant over others, to identify those that act as "hubs" around which others can be said to "revolve". Thus, if the network contains a number of propositions each linking the concept "cat" through a variety of predicates to a number of other concepts, then "cat" can be said to be dominant.

The information that enables the derivation and correct application of these rules is within the propositional network itself. This presupposes that the information in the database is in fact correct. For example, it is conceivable that a network contain the proposition "mammal ISA cat". If the information in the network is not correct, then the semantic component of the grammar must contain additional rules that check the propositions against other criteria in order to determine their veracity.

Pragmatics.

Generally, pragmatics is concerned with the behavioral effects of human communication (Watzlawick, Beavin and Jackson, 1967). We shall consider pragmatics in the narrower sense, following Kosslyn et. al. (1983), of the inferences that are drawn from a message and the context in which it occurs. It is here that the discrepancies occur between the intended meaning of semantically correct messages and what they actually mean to the receiver. The rules concerned with the pragmatic component of the grammar therefore deal with what inferences are likely to be made and the context in which the rules are being brought to bear. If we return for a moment to the idea of instructional design, presented right at the beginning of the paper, then we can see a parallel between the pragmatic component and the "conditions of instruction". The inferences that a person is likely to draw from a message are determined by a great variety of conditions (Salomon, 1981). These have to do with factors such as how much the person already knows about the conceptual domain in question (Tobias, 1976), the persons's aptitudes and mental skills (Cronbach and Snow, 1977), belief systems (Schoenfeld, 1983), perception of how much effort will have to be invested in processing the information (Salomon, 1982, 1983), and perception of the likelihood of success (Schunk, 1984). Collectively, these factors can be thought of as the context of the commununciation.

A great deal has been written about how all of these factors affect how people interpret messages, and about how messages should be constructed so as to minimize discrepancies between intended and perceived meaning that can be traced to these factors. These will not be presented here. Suffice it to say that we are here concerned with what has been addressed in a number of descriptive and prescriptive theories of instruction, which have been described in Reigeluth (1983), Gagne and Dick (1983), and elsewhere.

IMPLEMENTATION

In order to illustrate how a grammar of graphics, comprising syntactic, semantic and pragmatic rules, might operate, a program has been written that allows a user to interact with a database and to retrieve information from it in either textual or graphic formats. This program will now be described. In so doing, those aspects of the general model of ICAI not dealt with in much detail so far, the input parser and display routines, will be described in more detail. It is important to remember that the program was written to demonstrate how the various components might interact, and also that it does not have an instructional component. It simply allows a user, who might be a student, to interrogate a database and to retrieve information from it. In other words, it is concerned primarily with syntactic and semantic rules, and simply responds to requests from the user without diagnosing the user's needs or adapting output to suit the user's prior knowledge, styles, aptitudes, or perceptions. However, it is expected that an instructional component could be added to a system such as this, and that the principles demonstrated in the program would hold true for instructional applications.

Figure 3 illustrates the same general model as figures 1 and 2 and shows the particular details of the model as implemented in the program.

===================
Figure 3 about here
===================

Database.

The database consists of a semantic network (Norman and Rumelhart, 1975) made up of concepts (nodes) and predicates that describe how they are related. At present, the database may contain seventy concepts. A concept may be a member of a class of concepts (an elephant is a mammal), and may have other concepts subordinate to it (Fred is an elephant). A concept may have attributes (for example, an elephant has a trunk), and it may have qualities (an elephant is large). The location of a concept can be specified (the elephant is in the zoo). A concept can act (the elephant trumpets). It can act on another concept (the elephant eats hay), or it can bring about a particular effect (an elephant causes fear). In the database, concepts (elephant, mammal, Fred), as well as attributes, qualities, locations, actions, objects of actions and effects (trunk, large, zoo, trumpet, hay and fear) are all treated as concepts. This allows the easy construction of large hierarchies of classes and extended cause-and-effect chains. It also allows the construction of equivalents of "Object-Attribute-Value triplets" (Harmon and King, 1985), with constructions such as, "The cat has fur; the fur is white".

The database is not content-specific. It can contain any concepts the user wishes to place in it, and is created interactively by the user.

There are six predicates that describe how the concepts in the database are related:

1. ISA describes class membership (elephant ISA mammal).
2. HAS attaches attributes to a concept (elephant HAS trunk).
3. IS ascribes qualities to concepts (elephant IS large).
4. DOES ascribes actions to concepts (elephant DOES trumpet, elephant DOES eat hay).
5. LOC describes where a concept is located (elephant LOC zoo).
6. CAUSE establishes a cause-and-effect relationship between concepts (elephant CAUSE fear).

The database is organized as a matrix, with the concepts as row and column headings and the predicates, numbered one through six in the order of the list above, in the appropriate cells. If "elephant" were concept three and "mammal" concept nine, then the proposition "elephant ISA mammal" would be represented by placing a "1" in the cell where the third line intersected the ninth column. Negatives are stored as negative numbers, and when the DOES predicate involves an object of the specified action, the predicate is represented as 100 added to the number of the concept that is the object of the action. Thus with "elephant" as concept three, "eat" as concept 16, "hay" as concept nine, the proposition "elephant DOES not eat hay" would be represented by placing the number -109 at the intersection of the third and sixteenth columns, (minus for "not", 100 for DOES with object, plus 9 for "hay"). (Representing the information in the database in this way is appropriate for a program written in BASIC. With other languages, e.g. LISP or PROLOG, other structures would be more appropriate). By scanning along a row in the matrix, it is therefore very simple to retrieve a full description of any concept in the database, or to answer specific questions about it.

Program.

The program performs three main functions: database creation, database interrogation and database management. The last of these, involving the editing of the database, saving and loading database files, help, and so on, is straightforward and will not be discussed. The first will be described briefly, and the second at more length.

Database creation.

The interface contains a simple parser that interprets quasi-natural English statements. The user adds to the database by typing statements such as "A cat is an animal", "The elephant trumpets", "The elephant does not eat hamburger". The parser checks to see if the syntax of the statement is correct. If so, it looks to see if the concepts are already in the database. If not, it adds them. It then places the number representing the predicate in the appropriate location in the matrix.

Database Interrogation.

The parser also processes users' questions. Questions fall into two categories: those requiring yes or no answers, and those requiring constructed answers.

For the first category of questions, the parser treats predicate names as interrogatives. If the user asks "Does a cat drink milk?", the parser checks the syntax, and then sees whether "cat", "drink" and "milk" are in the database. If not, it tells the user. It then checks along the "cat" row of the matrix to see whether the predicate "DOES" (100) added the concept number for "milk" is in the "drink" column. It replies "Yes" or "No" accordingly".

For constructed questions, the parser recognizes "What" and "Which" as interrogatives. It responds to questions such as "What is a cat?", "What does an elephant eat?" by looking up the answer in the matrix, using the appropriate line for the concept named in the question. When the interrogative is "Which", the procedure is exactly he same, except it scans the column, not the row, corresponding to the named concept. Thus "What is an elephant?" yields "mammal", and "Which is an elephant?" gives "Fred". Similarly, "What does an elephant eat?" gives "hay", and "Which does eat the elephant?" would give, say, "lion".

The parser recognizes other interrogatives. "Describe" gives a complete description of the named concept. "Vocab" gives the list of concepts in the database. "Map" displays a map of the database. And "expert" engages a simple expert system which asks the user questions about a concept in the database in an attempt to guess what it is.

This brief description has assumed that the program has displayed text on the screen in response to questions. The program also operates in graphics mode, allowing the results of certain interrogations to be displayed as diagrams.

Graphics Mode.

All of the commands available in text mode are available in graphics mode. Graphics mode differs by providing some additional commands for zooming in and out on an image and for moving an image around the screen. It also differs in that it provides graphic answers to "what" and "which" interrogations. Thus, if the user types in "what is an elephant", the word "elephant" appears in a box beneath a box containing the word "mammal" to which it is joined by a vertical line labelled "is a". In response to "what does an elephant eat", a third box is added to the right of the elephant box containing the word "hay", joined to "elephant" with a line labelled "eat". At present, the graphics consist of labels, boxes and straight lines. However, there is no reason why concepts might not be represented by line drawings or icons of some sort.

The program contains a small grammar that allows it to display these graphics. The grammar consists of simple rules that embody some of the principles that were discussed in an earlier section. Bearing in mind that what the user sees on the screen is labels for predicates, concepts and their attributes, not pictures, these rules are:

1. Subordinate concepts are placed in boxes beneath the superordinate category to which they belong. (If more than one concept is subordinate to another, then it may be offset to the left or right of the position vertically below the superordinate category.)
2. Causes are placed to the left of their effects, agents to the left of their objects.
3. Predicates are expressed as labelled lines joining the two concepts whose relationship they describe. The labels for predicates are not placed in boxes.
4. The attributes and qualities of concepts and other characteristics, such as their location, are placed within the boxes that contain the concepts' labels.

In graphics mode, the parsing of input is identical to the way it is done in text mode. Thus the user can add to, edit and interrogate the database as before. Also, for all interrogations, other than "what" or "which", the answer is printed as text at the top of the screen. However, if the parser encounters "what" or "which" in a syntactically correct interrogation, the following processes occur:

1. If the concept named in the question is already on the screen, the program moves to step 2. If not, the screen is cleared and the concept is placed in its box in the middle of the screen.
2. The program seeks for the appropriate response. However, because it must now display a single concept, not a list, it must find the "closest" concept to the one named in the question. For example, an elephant is a mammal and an animal. In text mode, both would be provided as answers to "What is an elephant?". In graphics mode, only "mammal" must be displayed. Thus the program finds all possible responses in the appropriate row of the matrix, and then checks to see which is subordinate to which. The concept that has nothing subordinate to it except the concept named in the question is selected as the correct answer. The exceptions to this are answers to "which is a ..." questions, where any number of subordinate concepts can be displayed provided that they are all immediately subordinate to the first and all on the same "level" in the hierarchy.
3. The four rules described above are then applied. There are five possible outcomes:

i. If the interrogative is "what" and the predicate is ISA, then the response will be placed above the concept named in the question.

ii. If the interrogative is "what" and the predicate is DOES, the reponse will be placed to the right.

iii. If the interrogative is "which" and the predicate is ISA, then the response(s) will be placed below the named concept.

iv. If the interrogative is "which" and the predicate is DOES, then the response will be placed to the left.

v. If the interrogative is "what" and the predicate is one of IS, HAS, or LOC, then the response will be placed in the box beneath the concept's name.

4. The scale at which the diagram is to be drawn is then checked. If the user has "zoomed out" in order to be able to see more information on the screen at once, certain restrictions to the display apply. As the user "zooms out", the size of the boxes, and therefore the amount of information that they can contain, is reduced. After the first zoom out, only concept names can be included in the boxes, not attributes, values, locations and so on. Also, predicate labels cannot be displayed beside the lines joining the concepts. If the user zooms out further, then even the concept labels are lost. (Zooming in again restores the labels). Thus zooming out reduces the amount of detail about each concept that is presented, but improves the view of the whole pattern of the diagram.

5. The concept label in its box is added to the diagram on the screen. If the interrogation is "which is a ...", and there is more than one answer, then the concept labels in their boxes are drawn equally spaced side by side below the concept in the question.

6. Using information it has obtained in step three, the program determines which sides (top, bottom, left, right) of the boxes containing the first concept and the response are to be connected. The midpoints of these sides are calculated.

7. A line is drawn between the boxes.

8. For the ISA predicate, "is a" is printed beside the line.

9. For the DOES predicate, the name of the action ("eat", "chase") performed by the agent is placed beside the line.

10. The program processes the next input.

CONCLUSION

The program is a simple illustration of the kind of things that intelligent graphics might bring to computer-assisted learning. It embodies in a simple way some of the rules that might characterize a more fully-developed syntax of graphics. It exemplifies, through equally simple semantic rules, how information in a database might be meanigfully mapped onto syntactically legal graphic structures. However, it does not yet have an instructional component that would correspond to the pragmatic aspect of a complete grammar of graphics. To achieve this, attention must be given to the particular outcomes of instruction and the conditions under which it is to occur, with particular emphasis on student characteristics. In other words, the program needs to have a model of the learner to work from when the form in which onformation is to be presented.

We mentioned earlier that grammars are first and foremost descriptive of usage. This has implications for any further research that is conducted into the further development of a grammar of graphics for implementation in ICAI. It is not sufficient to conduct experimental studies of how different graphc formats help or hinder understanding. We have an immensely rich graphic tradition in our culture which is characterized more by informal conventions rather than by formal rules (Salomon, 1979, p.20). These conventions, primarily of non-notational systems, need detailed study with a view to making them more formal for application in notational systems, such as charts and diagrams. This represents an early phase in research whose aim is more the identification of possible hypotheses rather than hypothesis testing and requires an exhaustive study of graphics that are part of that tradition (see MacDonald-Ross, 1986, whose study of the historical development of chess manuals exemplifies this type of research). Experimental research can come later.

Let us not lose sight of the reason for the development of a grammar of graphics. While the effective graphics designer does not need to be consciously aware of a "grammar", any more than the successful novelist does, the computer needs to be programmed very specifically to deal with what is intuitively obvious to human graphic artists. Its potential for flexibility and adaptability to student needs (the "conditions" of instruction) relies on its ability to select strategies, including formats in which to present information, during interaction with a student. The computer needs to be able to "doodle" an explanatory graphic on the spur of the moment just as a teacher does. It is therefore no longer sufficient to build predrawn graphic displays into CAI programs. The computer can only achieve the flexibility it needs if, instead, it works with a database and a set of syntactic, semantic and pragmatic rules for converting the knowledge it has access to into an infinite variety of forms involving text and graphics. That is the ultimate goal towards which the program described in this paper makes but a small step.

References

Anderson, J.R., Boyle, C.F., and Yost, G. (1985). The Geometry Tutor. Pittsburgh: Carnegie Mellon University, Advanced Computer Tutoring Project.

Anderson, R.C. (1977). The notion of schemata and the educational enterprise. In R.C. Anderson, R.J. Spiro, & W.E. Montague (Eds). Schooling and the acquisition of knowledge. Hillsdale NJ: Lawrence Erlbaum. 415-431.

Berliner, D.C. (1986). In pursuit of the expert pedagogue. Educational Researcher , 15, No. 7, 5-13.

Bloom, B.S. (1984). The 2 sigma problem: The search for methods of group instruction as effective as one-to-one tutoring. Educational Researcher, 13, No. 6, 4-16.

Chomsky, N. (1965). Aspects of a theory of syntax. Cambridge MA: MIT Press.

Chomsky, N. (1962). Syntactic structures. S'Gravenhage: Mouton and Co.

Christopher, A. (1985). Artificial intelligence and computer graphics. Computer Graphics World, August, 11-20.

Cronbach, L.J., and Snow, R.E. (1977). Aptitudes and Instructional Methods. New York: Irvington.

Dwyer, F.M. (1978). Strategies for Improving Visual Learning. State College PA.: Learning Services.

Fleming, M.L., and Levie, W.H. (1978). Instructional Message Design: Principles from the Behavioral Sciences. Englewood Cliffs, NJ.: Educational Technology Publications.

Fowler, R. (1971). An instroduction to transformational syntax. New York: Barnes and Noble Inc.

Gagne, R.M., and Briggs, L.J. (1979). Principles of Instructional Design. New York: Holt, Rinehart and Winston, second edition.

Gagne, R.M., and Dick, W. (1983). Instructional psychology. Annual Review of Psychology, 34, 261-295.

Goodman, N. (1968). The Languages of Art. Indianapolis: Hackett.

Harmon, P., and King., D. (1985). Expert Systems. New York: John Wiley.

Hollan, J.D., Hutchins, E.L., & Weitzman, L. (1984). STEAMER: An interactive inspectable simulation-based training system. The AI Magazine, Summer, 15-27.

Holliday, W.G., Brunner, L.L., & Donais, E.L. (1977). Differential cognitive and affective responses to flow diagrams in science. Journal of Research in Science Teaching, 14, 129-138.

Knowlton, J.Q. (1966). On the definition of 'picture'. AV Communication Review, 14, 157-183.

Koran, M.L., & Koran, J. (1980). Interaction of learner characteristics with pictorial adjuncts in learning from science text. Journal of Research in Science Teaching, 17, 477-483.

Kosslyn, S., Simcox, W.A., Pinker, S., & Parkin, L.P. (1983). Understanding charts and graphs: A project in applied cognitive psychology. ERIC Document Reproduction Service, ED 238 687.

Larkin, J. (1985). Understanding, problem representations, and skill in Physics. In J.W. Segal & S.F. Chipman (Eds.). Thinking and Learning Skills, Vol. 2. Hillsdale: Lawrence Erlbaum.

MacDonald-Ross, M. (1986). Diagrams in scientific texts. Presented at the seminar on Illustration and Text, University of Tubingen, West Germany, July.

Neisser, U (1976). Cognition and Reality. San Francisco: Freeman.

Norman, D.A., Rumelhart, D.E. & LNR Research Group. (1975). Explorations in Cognition. San Francisco: Freeman.

Nunan, T, (1983). Countering Educational Design. New York: Nichols Publishing Company.

Rabinowitz, M., & Mandler, J.M. (1983). Organization and information retrieval. Journal of Experimental Psychology: Learning, Memory, and Cognition, 9, 430-439.

Reigeluth, C.M. (1983). Instructional design: What is it and why is it? In C.M. Reigeluth (Ed.), Instructional Design Theories and Models. Hillsdale, NJ.: Lawrence Erlbaum, 3-36.

Richey, R. (1986). The theoretical and conceptual bases of instructional design. London: Kogan Page.

Salomon, G. (1979). Interaction of Media, Cognition and Learning. San Francisco: Jossey Bass.

Salomon, G. (1981). Communication and Education: Social and

Psychological Interaction. Beverly Hills, CA.: Sage.

Salomon, G. (1982). The differential investment of mental effort in learning from different sources. Annual conference of the American Educational Research Association, New York, March.

Salomon, G. (1983). How students decide when to invest more mental effort in learning. Annual conference of the American Educational Research Association, Montreal, April.

Salomon, G. (1983). The differential investment of mental effort in different sources of learning material. Educational Psychologist, 18, 42-50.

Schank, R.C. (1984). The Cognitive Computer: On Language, Learning and Artificial Intelligence. Reading, MA.: Addison-Wesley.

Schank, R.C., and Abelson, R.P. (1977). Scripts, Plans, Goals and Understanding. Hillsdale, NJ.: Lawrence Erlbaum.

Schlichtmann, H. (1985). Characteristic traits of the semiotic system "Map symbolism". The Cartographic Journal, 22, 23-30.

Schoenfeld, A.H. (1983). Beyond the purely cognitive: Belief systems, social cognitions and metacognitions as driving forces in intellectual performance. Cognitive Science, 7, 329-363.

Schon, D. A. (1983). The Reflective Practitioner: How Professionals Think in Action. New York: Basic Books, Inc.

Schunk, D.H. (1984). Self-efficacy perspective on achievement behavior. Educational Psychologist, 19, 48-58.

Sleeman, D., and Brown, J.S. (1982). Intelligent Tutoring Systems. New York: Academic Press.

Szlichcinski, K.P. (1980). The syntax of pictorial instruction. In P.A. Kolers, M.E. Wrolstad, and H. Bouma, (Eds.), Processing Visible Language Volume II. New York: Plenum Press.

Thorndyke, P.W., & Hayes-Roth, B. (1979). The use of schemata in the acquisition and transfer of knowledge. Cognitive Psychology, 11, 82-106.

Tobias, S. (1976). Achievement treatment interactions. Review of Educational Research, 46, 61-74.

Watzlawick, P., Beavin, J.H., & Jackson, D.D. (1967). Pragmatics of human communication: A study of interactional patterns, pathologies and paradoxes. New York: Norton.

Wertheimer, M. (1938). Laws of organization in perceptual forms in a source book for Gestalt psychology. London: Routledge and Kegan Paul.

Winn, W.D. (1982). The role of diagrammatic representation in learning sequences, identification and classification as a function of verbal and spatial ability. Journal of Research in Science Teaching, 19, 79-89.

Winn, W.D. (1983). Perceptual strategies used with flow diagrams having normal and unanticipated formats. Perceptual and Motor Skills, 57, 751-762.

Winn, W.D. (in press). Instructional design and intelligent systems: Shifts in the designer's decision-making role. Instructional Science.

Winn, W.D. (1986a).Instructional design and self-designing systems. Educational Technology, 26.

Winn, W.D. (1986b). The design and use of instructional graphics. Presented at the seminar Illustration and Text, University of Tubingen, West Germany, July.

ICAI Model

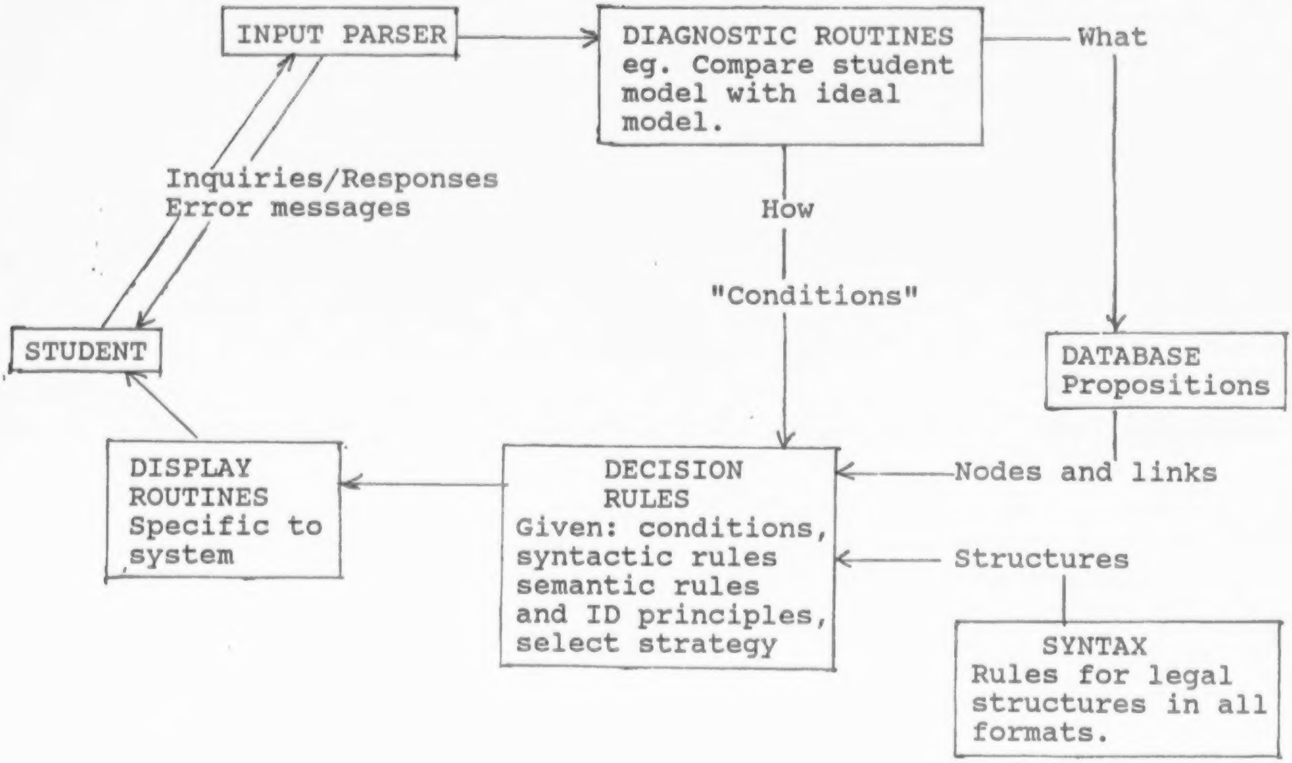

INPUT PARSER
DIAGNOSTIC ROUTINES eg. Compare student model with ideal model.
What
Inquiries/Responses
Error messages
How
"Conditions"
STUDENT
DATABASE Propositions
DISPLAY ROUTINES Specific to system
DECISION RULES Given: conditions, syntactic rules semantic rules and ID principles, select strategy
Nodes and links
Structures
SYNTAX Rules for legal structures in all formats.

Figure 1

Linguistic Model

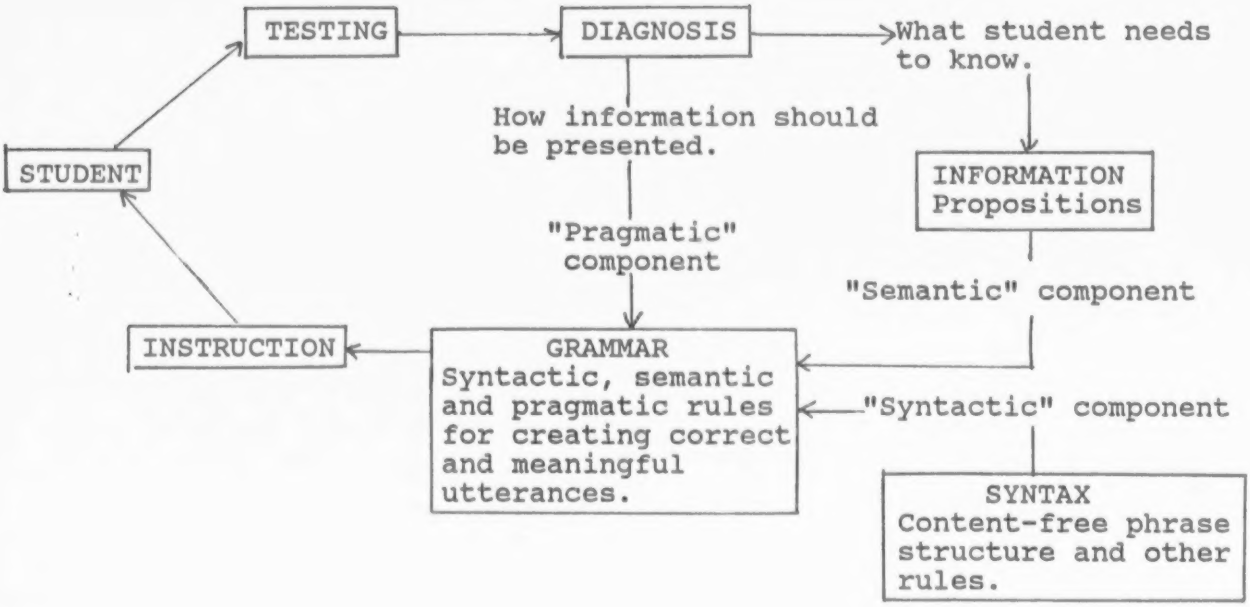

TESTING
DIAGNOSIS
What student needs to know.
STUDENT
How information should be presented.
INFORMATION Propositions
"Pragmatic" component
"Semantic" component
INSTRUCTION
GRAMMAR Syntactic, semantic and pragmatic rules for creating correct and meaningful utterances.
"Syntactic" component
SYNTAX Content-free phrase structure and other rules.

Figure 2

Program Model

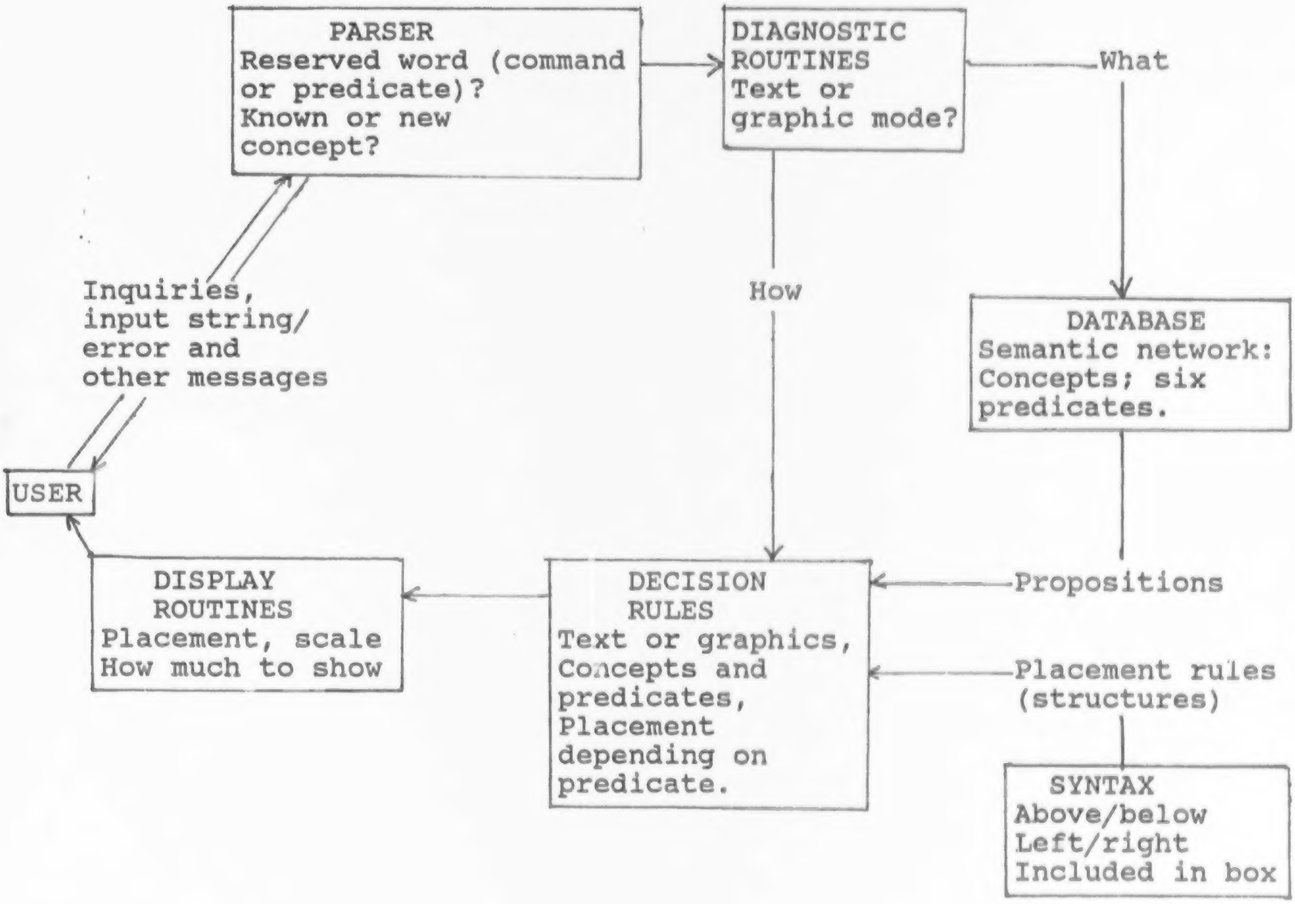

PARSER
Reserved word (command or predicate)?
Known or new concept?
DIAGNOSTIC ROUTINES
Text or graphic mode?
What
How
DATABASE
Semantic network:
Concepts; six predicates.
Inquiries, input string/ error and other messages
USER
DISPLAY ROUTINES
Placement, scale
How much to show
DECISION RULES
Text or graphics,
Concepts and predicates,
Placement depending on predicate.
Propositions
Placement rules (structures)
SYNTAX
Above/below
Left/right
Included in box

Figure 3

Electronic Text Display:

An Experiment on Page Turning and Window Effect

Andrew R. J. Yeaman,
Assistant Professor of Education
Winther Hall 6053,
College of Education, Dept. EF/CE
University of Wisconsin--Whitewater,
Whitewater, WI 53190-1790
(414) 472-1940

A paper presented to the Research and Theory Division of the
Association for Educational Communications and Technology,
Atlanta, Georgia.
February, 1987.

Abstract

Readers of electronic text view the text through a window formed by an area of the display screen. To evaluate the restriction that electronic text makes on readers by limiting random access to those windows, subjects in this experiment read passages from a reading test. There were two levels of window: a single window containing a whole passage and multiple windows of six lines each. Reading took place under two conditions: restricted and unrestricted page turning. There were two dependent measures: comprehension and speed of reading. Directional restriction on linear reading had no significant effect on comprehension but free turning back to previous windows was significantly detrimental in terms of reading speed for either proportion of window. The two levels of window were not significantly different. This raises the question of reader access to text versus reading efficiency and presents a new objective to designers of electronic displays for reading.

Electronic Text Display: An Experiment on Page Turning and Window Effect

The technology of text displayed on printed paper developed through trial and error over several centuries but the display of continuous prose on electronic screens is becoming widespread without the benefit of testing beyond the visibility of individual characters. This appears as a research issue in several forms (Cushman, 1986, Kak, 1981; Kolers, Duchnicky and Ferguson, 1981; Muter, Latremouille, Treurniet and Beam, 1982; Snyder and Maddox, 1978). Empirical recommendations for legible printing on paper are given by Tinker's safety zones for print (1963) and are considered in the design of printed text as meaningful, running prose. The major variables for the usual black on white, upper and lower case printing are character size, line length and interline spacing; these vary with the font and style of type. Design decisions for reading electronic text have been based on the distinction of discrete alphanumerics rather than actual reading (Gould, 1968, Shurtleff, 1980; Smith, 1979). This is due to the initial applications of display devices such as cathode ray tubes for military control and command tasks. In contrast, a predominant mode of information delivery is text and it is increasingly conveyed by display screens.

The substantial difference between the old and the new reading media requires empirical investigation. As hard copy, pages are their own storage medium and their own display medium. As soft copy, the screen must draw upon a secondary storage medium, such as a disk or a chip. This difference changes the technology of reading beyond traditional legibility variables. Two new variables to consider in this respect are the size of the window into the text and the freedom of access to these windows.

Window

Readers of electronic text view the text through a window formed by an area of the display screen. A printed page, such as this one, is also a window into the text. However, a printed page is a much larger window than that of electronic text displays affordable at present. Several screen windows would be needed to convey this page.

Hartley reports that the research literature has not been useful in determining the pagesize of printed instructional text (1978, p. 9-12) but identifies its importance as the basic design unit. Window is the electronic version of pagesize and has the equivalent interaction with other text elements, including the major variables. Unlike the pagesize of printed paper, the window of an electronic screen is limited--even in bit-mapped displays.

Though it is arbitrarily assigned like a page in a book, the window into the text can itself be a unit of meaning. The meaning of a window is what the readers attribute to it from the text displayed there. Raban's psycholinguistic study (1982), for example, indicated that the effect of printed text display on line length and line-breaks influences children's understanding of sentences. Similarly, reading an electronic text display may not induce a different psychological reading process from reading printed paper but may induce a different problem solving process. Waern and Rollenhagen provide commentary on this in their review paper (1983). When only a small window is allowed, readers may cope by adopting alternative cognitive strategies: the window effect (Yeaman,1984).

Page turning

Free access to the text is a function of the size of the text window. As the number of screens bearing certain size windows increases, turning the page and unifying the mental image of each window's contents assumes a greater load on the reader's mental processing. An increase in the number of windows acts to lower comprehension. It is not known at what point there is an impairment in reading performance. It is safe to say that such a point probably exists.

Electronic text presents a new restriction to readers by limiting random access to windows. Paging is allowed in text editors, for instance, by one programmed function key for forward and another for back. This window mode is sequential in comparison to a book: the screen must fill before another window of text can be displayed.

Purpose

The purpose of this study was to seek empirical evidence of these two new variables as window effect and page turning. The variables were operationalized as two proportions of window and two page turning conditions for text access. Reading performance was evaluated by reading speed and comprehension, two measures theoretically based on the psychophysiological correlates of reading (Just and Carpenter, 1980). Reading speed and comprehension respectively represent partly distinct abilities that vary separately in individuals: visual word processing and nonvisual, linguistic processing (Palmer, MacLeod, Hunt and Davidson, 1985).

METHOD

Subjects

The target population was adult readers: a population containing approximately equal numbers of men and women who vary in reading ability, visual acuity and age. Subjects were 61 undergraduates drawn from spring term classes and offered extra credit for participation.

Instrumentation

The use of the 13-14 grade Sequential Test of Educational Progress (STEP) Series II Form A, a standardized, normed reading test, allowed a more realistic measure of reading performance than scanning rate or letter recognition threshold. A standardized, normed reading test demonstrates consistent reliability and validity over reading tests piloted with small numbers of readers (Carmichael and Dearborn, 1947, p. 239). In the experiment, there were 2 sets of 2 equivalent narrative prose passages and, in each administration, the students were asked to answer the 9 multiple choice questions on their 2 passages within 10 minutes.

Materials

The reading tests were displayed as photocopied dot matrix print in simulation of electronic text. The font produced by the Okidata 92 printer resembled 10 point type and the test passages were set up in approximation of Tinker's recommendations

(1963). The lines were single spaced and 52 characters in line length. The left margin was even and the lines were unjustified with a ragged right margin. In the single window display each text passage was visible as one complete window. In the multiple windows display the text for each passage was displayed through windows of six lines each--causing these passages to be presented through seven windows. Turning back to reread earlier text was prohibited in the restricted page turning administration. The students were expressly told in the unrestricted page turning administration that they could look back. The comprehension questions were displayed identically in each treatment.

Procedure

Students read the printed, formatted text in class group administrations. They read through the text by turning the page forward or, in the unrestricted page turning condition, by turning it forward and back. Students recorded their time of completion by writing it down in hours, minutes and seconds from a classroom wall clock. Responses to the STEP multiple choice questions were marked on printed answer sheets.

The procedures were identical for all treatments except that the text was displayed through different proportion windows and with or without restrictions on page turning for looking back. Students were randomly assigned to the window size groups. Single window passages were read by 28 students and another 30 students read multiple window passages. Twenty four students were randomly selected for the free text access condition--unrestricted page turning. These students were assigned the window treatment to which they had previously been exposed. They were joined by 3 new students so that 11 students read single window passages and 16 students read multiple window passages. A written script was followed to guide events closely to normal STEP administration.

RESULTS

Reading speed

A two-way analysis of variance was performed on the reading speeds for the 85 cases. Reading time was taken as the indication of speed. The mean times, in seconds, for the single window and the multiple windows groups respectively were 478.43 and 509.73, in the restricted page turning condition, and 552.36 and 560.94 in the unrestricted page turning condition. There were no significant differences for reading speed between the window treatment groups. There was a significant main effect for reading speed for both window treatment groups under restricted or unrestricted page turning, $F(1, 81) = 10.57$, $p < 0.01$, see Figure 1.

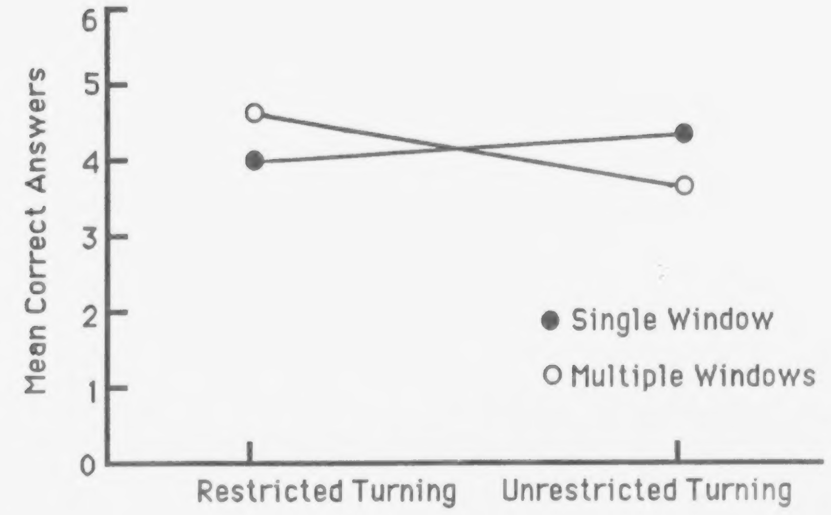


Figure 1. *The reading speed of the window groups changed with the page turning condition.*

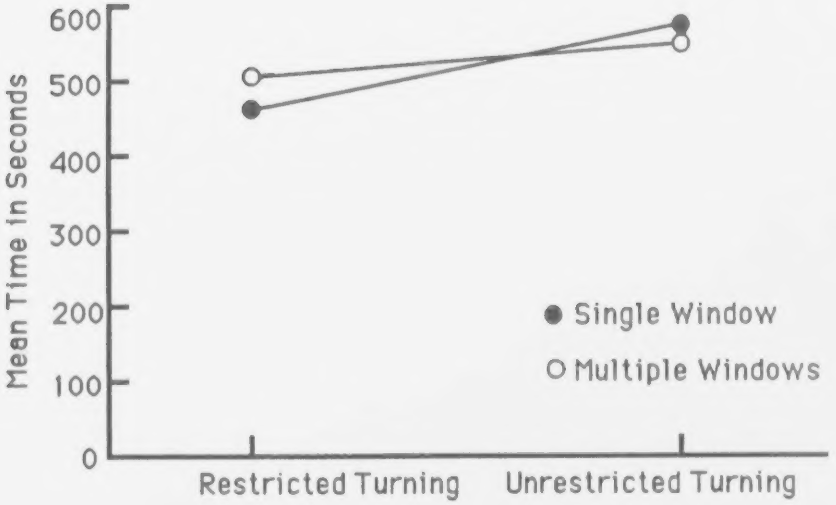


Figure 2. *The comprehension of the window groups changed with the page turning condition.*

Comprehension

A two-way analysis of variance was performed on the scores. The mean reading scores for the single window and the multiple windows groups respectively were 4.00 and 4.53, in the restricted page turning condition, and 4.36 and 3.75 in the unrestricted page turning condition. There were no significant differences for the number of correct answers between any window treatment group, whether under restricted or unrestricted page turning.

Further Analysis

The relationships of the mean scores for correct answers is anomalous, see Figure 2. The single window score went up and the multiple windows score went down in the unrestricted page turning condition. This relationship was investigated further and the window groups' responses were compared with two-way analysis of variance for accuracy in answering the questions following each passage in each condition.

On the first comprehension questions in the restricted page turning condition, the one window per passage group scored lower ($\underline{M} = 1.21$) than the multiple windows group ($\underline{M} = 1.90$). For the first set of questions under unrestricted page turning the positions were reversed and the one window per passage group ($\underline{M} = 2.55$) did better than the multiple windows group ($\underline{M} = 2.44$). Two-way analysis of variance showed no significant difference between the levels of window but did show a significant difference between the page turning conditions: $\underline{F}\,(1,81) = 10.25$, $\underline{p} < 0.01$, see Figure 3.

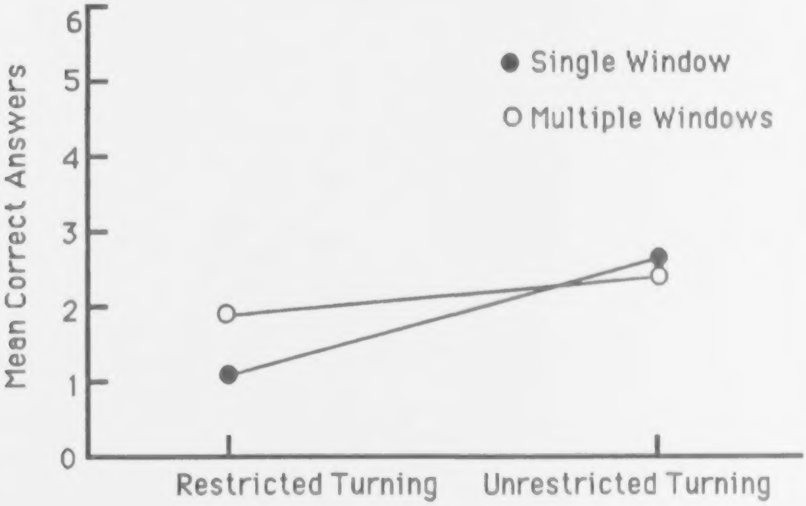


Figure 3. *Relative to the first questions, the comprehension of the window groups changed with the page turning condition.*

On the last comprehension questions in the restricted page turning condition, the one window per passage group scored higher ($M = 2.79$) than the multiple windows group ($M = 2.63$). For the second set of questions under unrestricted page turning the positions remained the same and the one window per passage group ($M = 1.82$) did better than the multiple windows group ($M = 1.31$). Two-way analysis of variance showed no significant difference between the levels of window but did show a significant difference between the page turning conditions: $F(1,81) = 17.08$, $p < 0.001$, see Figure 4.

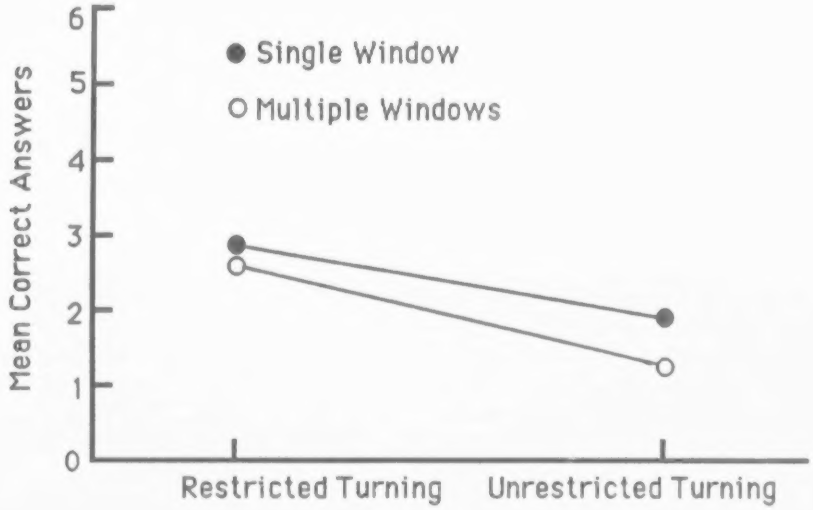


Figure 4. *Relative to the last questions, the comprehension of the window groups changed with the page turning condition.*

Analysis of Reading Speed Decrease for Linear Relationships

Examination of the raw data indicated the likelihood of a linear relationship between the decrease of reading speed under unrestricted page turning and the students' fastest reading speeds. Correlation confirmed this interpretation for the single window group: $r = -0.62$, $p < 0.5$, slope = -0.90 and intercept = 543.01. A linear relationship was also established for the multiple window group: $r = -0.91$, $p < 0.001$, slope = -1.17 and intercept = 590.77. These results indicate that the slower the reading speed, the smaller the loss of reading speed in the unrestricted page turning condition and, conversely, the faster the reading speed, the larger the loss of reading speed in the unrestricted page turning condition.

DISCUSSION

The data empirically support the importance of page turning in text access. This was demonstrated by the comparison of reading speeds for restricted and unrestricted page turning. Readers apparently prefer to take the time required in unrestricted page turning

]

for looking backwards and forwards in the text--although no significant improvement in comprehension was found.

The effect of different proportions of window on reading speed and comprehension were not significant. This does not mean there are no differences, only that none were detected. Under restricted page turning, the single window group tended to be less efficient than the multiple windows group but the positions reversed for unrestricted page turning, see Figures 1 and Figure 2. A conjectural explanation for the reversal is that the degree of text access affected cognitive load to induce a varying trade off between reading speed and comprehension, between visual and linguistic processing.

Since text access has been shown to be a significant variable then it may be conjectured that window could also have an effect. Length of passage is another variable to consider: a passage 4 times as long would require 4 windows at one level and 28 at the other level. It is reasonable to expect that many small windows will detract from reading peformance when compared with few large windows.

The multiple windows group tended to comprehend more than the single windows group in the restricted page turning condition and tended to comprehend less in the unrestricted page turning condition, see Figure 2. As illustrated by the post hoc analysis, this conclusion is limited by the single window group appearing adversely affected by warm up on the first passage: they did better on the second passage, having had a reading trial. It is possible the single window group did not read closely enough to do well on the first questions but this experience prepared them for the second passage. It is also possible that the multiple windows, being smaller, caused closer reading in the other group.

The single window group improved on the first questions under the condition of unrestricted page turning, see Figure 3, and did best on the last questions each time, see Figure 4. These differences between the groups were not significant. However, neither window group did significantly as well on the last questions under unrestricted page turning as they did under restricted page turning. It may be that they ran out of time. The human factoring of electronic reading must address these performance inequities.

The analysis of reading speed decreases indicate linear relationships between reading speed and the page turning condition. Access to electronic text may need to be different for different types of readers. Flexibility in reading display design is suggested to accommodate both slow readers and fast readers.

Reading behavior is a product of the reader's interest and ability, as moderated by perceptual and typographic factors. It may vary from one passage to another in addition to being dependent on the characteristics of each individual. For instance, in reviewing individual differences in response to computerized instruction Eberts and Brock (1984) refer to Larkin's observations (1981). Larkin reports that students doing physics practice problems differed in their reading behavior according to ability: *Poor students read through the text sequentially whereas good students used it as a reference source and jumped around in it, accessing it at random.* Eberts and Brock use this data to refer to the branching aspects of computerized programmed instruction and suggest the capability of exploring text onscreen in a nonlinear fashion be part of the student-computer interface.

Comments from students reading text from microcomputer screens under similar experimental conditions as the study reported here reflect on the acceptability of the screen reading experience (Yeaman, 1984). There were many suggestions that the text would have been easier to comprehend had it been broken up into meaningful units on the screen rather than arbitrary windows. Many students preferred that sentences, at least, not be split from one screen to the next, although this is commonplace in books and periodicals with which they had much prior experience. In the ensuing discussions, students qualified this by comparison with the printed page where it is possible to turn back to the previous page as a check on meaning. It was quite clear from the students that reader control to go back in the text was very desirable: they wanted to check their understanding to give good answers. In addition, books as a familiar reading medium always allow this level of random access.

This converges with the two main reasons why people read that are identified by Smith (1982). Efferent reading is reading for instruction and can be readily evaluated through testing comprehension: the reader's absorption of information and inferences made as a consequence. Aesthetic reading is for enjoyment; reading for its own sake. Real life reading outside the laboratory--whether to acquire facts or experience pleasure or a mixture--is self-paced and page turning, forward and back, is under the reader's control. The question is how to best maintain that tradition for all readers with the shift to electronic delivery.

CONCLUSIONS

The development of electronic reading media not only incorporates the traditional aspects of typographic legibility and the novel aspects of light emitting displays (Wilkins, 1986) but also some new issues in text access (Line, 1980, 1981). The study reported here indicates significant changes in reading speed relative to the text access afforded by page turning conditions. The interaction of page turning and window effect suggests structuring the text image to avoid paging back and forth, sequentially through a succession of windows. For example, an electronic book could be developed as a visually organized database with an open text window onscreen and iconic representations of immediate access points.

REFERENCES

Carmichael, L. and Dearborn, W. F. (1947). Reading and visual fatigue. Boston: Houghton Mifflin.

Cushman, W. H. (1986). Reading from microfiche, a VDT, and the printed page: Subjective fatigue and performance. Human Factors, 28, 63-73.

Eberts, R. and Brock, J. F. Computer applications to instruction. In F. A. Muckler (Ed.), Human factors review: 1984 (pp. 239-284). Santa Monica, CA: Human Factors Society.

Gould, J. D. (1968). Visual factors in the design of computer-controlled CRT displays. Human Factors, 10, 359-376.

Hartley, J. (1978). Designing instructional text. New York: Nichols.

Just, M. A. and Carpenter, P. A. (1980). A theory of reading: From eye fixations to comprehension. Psychological Review, 87, 329-354.

Kak, A. V. (1981). Relations between readability of printed and CRT-displayed text. In Proceedings of the Human Factors Society 25th Annual Meeting (pp. 137-140). Santa Monica, CA: Human Factors Society.

Kolers, P. A., Ducknicky, R. L. and Ferguson, D. C. (1981). Eye movements measurement of readability of CRT displays. Human Factors, 23, 517-527.

Larkin, J. H. (1981). Enriching formal knowledge: A model for learning to solve problems in physics. In J. R. Anderson (Ed.), Cognitive skills and their acquisition. Hillsdale, NJ: Erlbaum.

Line, M. B. (1980). Some questions concerning the unprinted word. In P. J. Hills (Ed.), The future of the printed word: The impact and implications of the new communications technology (pp. 27-35). Westport, CT: Greenwood Press.

Line, M. B. (1981). Redesigning information packages for electronic transmission. In K. P. Jones and H. Taylor (Eds.), The design of information systems for human beings: Informatics 6 (pp. 29-39). London: Aslib.

Muter, P., Latremouille, S. A., Treurniet, W. C. and Beam, P. (1982). Extended reading of continuous text on television screens. Human Factors, 24, 501-508.

Palmer, J., MacLeod, C. M., Hunt, E. and Davidson, J. E. (1985). Information processing correlates of reading. Journal of Memory and Language, 24, 59-88.

Raban, B. (1982). Text display effects on the fluency of young readers. Journal of Research in Reading, 5, 7-28.

Shurtleff, D. A. (1980). How to make displays legible. La Mirada, CA: Human Interface Design.

Smith, F. (1982). Understanding reading: A psycholinguistic analysis of reading and learning to read. New York: Holt, Rinehart and Winston.

Smith, S. L. (1979). Letter size and legibility. Human Factors, 21, 661-670.

Snyder, H. L. and Maddox, M. E. (1978). Information transfer from computer-generated dot-matrix displays. (HFL-78-3/ARO-78-1) Research Triangle Park, NC: U.S. Army Research Office (NTIS No. AD-AO63 505).

Tinker, M. A. (1963). Legibility of print. Ames, IO: Iowa State University Press.

Waern, Y. and Rollenhagen, C. (1983). Reading text from visual display units (VDUs). International Journal of Man-Machine Studies, 18, 441-465.

Wilkins, A. (1986). Intermittent illumination from visual display units and fluorescent lighting affects movements of the eyes across text. Human Factors, 28, 75-81.

Yeaman, A. R. J. (1984). Electronic books and legibility: A microcomputer simulation. (Doctoral dissertation, University of Washington, 1984). Dissertation Abstracts International, 45, 1273A.

1985-1987 CUMULATIVE AUTHOR INDEX

AUTHOR'S NAME	DESCRIPTOR	YR/PG
ABRAMS, A.	INTERACTIVE VIDEO	86/1
ABRAMS, A.	PHOTOGRAPHY SKILLS	86/1
AEGERTER, R.	LEARNING STYLES	85/750
AEGERTER, R.	PERSUASION	85/750
ALBRIGHT, M.J.	INCENTIVE	85/1
ALBRIGHT, M.J.	ALGEBRA	85/1
ALEAMONI, L.M.	LIBRARY MANAGEMENT	86/252
ALESANDRINI, K.	COURSEWARE	85/18
ALESANDRINI, K.	GRAPHICS	85/18
ALLEN, B.S.	ANALOGICAL REASONING	87/471
ALLEN, B.S.	COMPARISON STRATEGIES	85/29
ALLEN, B.S.	ACQUISITION SKILLS	85/29
ALLEN, B.S.	DIAGRAMS	87/471
AMEDEO, D.	TEXT LAYOUT	85/280
ANAND, P.	COMPUTER-BASED INSTRUCTION	87/639
ANASTASOFF, J.	COMPUTERS	85/703
ANGLIN, G.J.	RECALL	87/49
ANGLIN, G.J.	RECALL	86/15
ANGLIN, G.J.	PICTURES	87/49
ANGLIN, G.J.	ILLUSTRATIONS	85/57
ANGLIN, G.J.	PICTURE EFFECTS	86/15
ANGLIN, G.J.	PROSE	85/57
AUST, R.J.	PERCEPTUAL PROCESSES	87/63
AUST, R.J.	INTROVERTED APPROACH	87/63
BAKER, P.	COMPUTER-BASED INSTRUCTION	85/146
BAKER, P.	COMPUTER-BASED INSTRUCTION	87/709
BAKER, P.	INSTRUCTIONAL STRATEGY	86/65
BAKER, P.	INDIVIDUAL DIFFERENCES	85/146
BAKER, P.	LEARNING STRATEGIES	87/709
BAKER, P.R.	SCREEN DESIGN	86/36
BAKER, P.R.	COMPUTER GRAPHICS	86/36
BAKER. P.	PACING	86/65
BECKER, A.	RESEARCH	85/72
BECKER, A.	THEORY	85/72
BECKER, A.D.	MEDIA ANALYSIS	87/83
BECKER, A.D.	READER THEORIES	87/83
BELLAND, J.	INSTRUCTIONAL STRATEGY	86/177
BELLAND, J.	COMPUTER-BASED INSTRUCTION	85/146
BELLAND, J.	PACING	86/65
BELLAND, J.	ENCODING	85/87
BELLAND, J.	LEARNING STRATEGIES	87/709
BELLAND, J.	COMPUTER-BASED INSTRUCTION	87/709
BELLAND, J.	INDIVIDUAL DIFFERENCES	85/146
BELLAND, J.	INSTRUCTIONAL DESIGN	85/87
BELLAND, J.C.	SCREEN DESIGN	86/36
BELLAND, J.C.	COMPUTER GRAPHICS	86/36
BENDER, E.	MICROCOMPUTER SOFTWARE	87/99
BENDER, E.	EVALUATION	87/99
BERRY, T.	LEARNING STYLES	85/750
BERRY, T.	PERSUASION	85/750
BOWIE, M.M.	FILM	86/49
BOWIE, M.M.	LEARNING STYLES	86/49
BRATTON, B.	GRADUATE EDUCATION	86/421
BRATTON, B.	CURRICULUM CHANGES	86/421
BROVEY, A.J.	INTERACTIVE VIDEO	87/152

BROVEY, A.J.	VIDEODISC	87/152
CAMBRE, M.A.	COMPUTER GRAPHICS	86/36
CAMBRE, M.A.	SCREEN DESIGN	86/36
CANELOS, J.	INSTRUCTIONAL STRATEGY	86/65
CANELOS, J.	LEARNING STRATEGIES	85/848
CANELOS, J.	NOTETAKING	85/848
CANELOS, J.	COMPUTER-BASED INSTRUCTION	87/709
CANELOS, J.	LEARNING STRATEGIES	87/709
CANELOS, J.	INDIVIDUAL DIFFERENCES	85/146
CANELOS, J.	PACING	86/65
CANELOS, J.	ENCODING	85/87
CANELOS, J.	LEARNING STRATEGIES	85/848
CANELOS, J.	INSTRUCTIONAL DESIGN	85/87
CANELOS, J.	COMPUTER-BASED INSTRUCTION	85/146
CARL, D.L.	COMPUTERS	86/85
CARL, D.L.	ATTITUDES	86/85
CARL, R.R.	ATTITUDES	86/85
CARL, R.R.	COMPUTERS	86/85
CHARTRAND, S.	COMPUTERIZED IMAGES	87/481
CHARTRAND, S.	TELEVISION	87/481
CHRISTENSEN, D.L.	MAIS	87/119
CHRISTENSEN, D.L.	COMPUTER-BASED INSTRUCTION	87/119
CHU, H.J.	READING	87/133
CHU, H.J.	COMPUTER-ASSISTED INSTRUCTION	87/133
CHUTE, A.G.	MEDIA UTILIZATION	86/106
CHUTE, A.G.	TELETRAINING	86/106
CLARK, R.E.	RESEARCH	87/1
COLAMAIO, M.E.	INTERACTIVE VIDEO	87/297
COLAMAIO, M.E.	LOCUS OF CONTROL	87/297
COLAMAIO, M.E.	PRACTICE	87/297
COOK, S.	LEARNING STYLES	85/750
COOK, S.	PERSUASION	85/750
CUSHALL, M.B.	INTERACTIVE VIDEO	87/152
CUSHALL, M.B.	VIDEODISC	87/152
DALTON, D. W.	ATTITUDE	86/119
DALTON, D.W.	REINFORCEMENT	85/101
DALTON, D.W.	COMPUTER-BASED REINFORCEMENT	85/101
DALTON, D.W.	TELEVISION	87/161
DALTON, D.W.	WRITING SKILLS	86/166
DALTON, D.W.	ATTITUDE	86/153
DALTON, D.W.	MEDIA UTILIZATION	86/153
DALTON, D.W.	NARROW-CAST TELEVISION	87/161
DALTON, D.W.	WORD PROCESSING	86/166
DALTON, D.W.	EFFICACY OF LOGO	86/119
DALTON, D.W.	LOGO LANGUAGE	86/562
DEGRAFF, J.	TELEVISION	85/125
DEGRAFF, J.	FILM THEORY	85/125
DEMPSEY, J.V.	TRANSFER OF LEARNING	87/337
DEMPSEY, J.V.	ATTENTION REDUCTION TRAINING	87/337
DERRY, S.J.	ARITHMETIC WORD PROBLEMS.	87/745
DERRY, S.J.	SCHEMA THEORY	87/745
DRISCOLL, M.P.	APTITUDE-TREATMENT INTERACTION	87/171
DUDT, K.P.	AFFILIATED CABLE TELEVISION	86/185

DUDT, K.P.	TELEVISION	86/195
DUDT, K.P.	TELEVISION	86/185
DUDT, K.P.	AFFILIATED CABLE TELEVISION	86/195
DWYER, C.A.	PRACTICE STRATEGIES	87/183
DWYER, C.A.	VISUALIZED INSTRUCTION	87/183
DWYER, F.	LEARNING STRATEGIES	85/848
DWYER, F.	COMPUTER-BASED INSTRUCTION	85/146
DWYER, F.	INSTRUCTIONAL DESIGN	85/87
DWYER, F.	INDIVIDUAL DIFFERENCES	85/146
DWYER, F.	NOTETAKING	85/848
DWYER, F.	LEARNING STRATEGIES	87/709
DWYER, F.	PACING	86/65
DWYER, F.	COMPUTER-BASED INSTRUCTION	87/709
DWYER, F.	ENCODING	85/87
DWYER, F.	INSTRUCTIONAL STRATEGY	86/65
ELLSWORTH, E.	INSTRUCTIONAL DESIGN	87/205
ELLSWORTH, E.	FILM - HISTORICAL ANALYSIS	87/205
ERDMAN, B.	FILM	87/221
ERDMAN, B.	SOCIAL ISSUES	87/221
EVANS, L.J.	MEDIA SELECTION	86/210
FELT, S.B.	GRADUATE EDUCATION	86/302
FELT, S.B.	MANAGEMENT	86/302
FORMAN, G.E.	COGNITION	85/164
FORMAN, G.E.	VIDEO	85/164
FOSNOT, C.T.	VIDEO	85/164
FOSNOT, C.T.	COGNITION	85/164
FRENCH, M.	INSTRUCTIONAL STRATEGIES	85/193
FRENCH, M.	ANALYTIC ABILITY	85/193
FRENCH, M.	RESEARCH	85/220
FRENCH, M.	INSTRUCTION	85/220
GAGNE, R.M.	SCHEMA THEORY	87/229
GAGNON, R.	INSTRUCTIONAL TECHNOLOGY	85/232
GAMSKY, D.	COMPUTERS	85/318
GAMSKY, D.	TEACHER SOCIALIZATION	85/318
GARDNER, C.H.	ELECTRONIC MAIL	86/220
GARHART, C.	COMPUTER-BASED INSTRUCTION	86/230
GARHART, C.	COMPUTER-BASED INSTRUCTION	86/336
GARHART, C.	COMPUTER-BASED INSTRUCTION	86/336
GARHART,C.	COGNITIVE MONITORING	86/230
GJERDE, C.L.	GRADUATE EDUCATION	86/421
GJERDE, C.L.	CURRICULUM CHANGES	86/421
GOETZFRIED, L.	COMPUTER-ASSISTED INSTRUCTION	85/252
GOETZFRIED, L.	MATHEMATICS	85/252
GOTHBERG, H.M.	TIME MANAGEMENT	86/252
GOTHBERG, H.M.	LIBRARY MANAGEMENT	86/252
GRABINGER, R. S.	COMPUTER-GENERATED TEXT	86/271
GRABINGER, R.S.	TEXT LAYOUT	85/280
GRABINGER, R.S.	TEXT FORMAT	86/271
GREATHOUSE, S.	ATTITUDES	86/85
GREATHOUSE, S.	COMPUTERS	86/85
GREENE, E.C.	RECALL	87/235
GREENE, E.C.	TELEVISION	87/235
GRIBBLE, M.	COMPUTERS	85/318

GRIBBLE, M.	TEACHER SOCIALIZATION	85/318
GRIFFIN, S.M.	LITERACY	87/247
GRIFFIN, S.M.	PERCEPTUAL MODE	87/247
GUEULETTE, D.G.	PSYCHOTECHNOLOGY	87/259
GUEULETTE, D.G.	CONSCIOUSNESS	87/259
HALES, R.L.	MANAGEMENT	86/302
HALES. R.H.	GRADUATE EDUCATION	86/302
HANCLOSKY, W. V.	TASK ANALYSIS	86/313
HANCLOSKY, W.V.	ADVANCE ORGANIZER	86/313
HANNAFIN, M.	COMPUTER-BASED INSTRUCTION	86/230
HANNAFIN, M.	COGNITIVE MONITORING	86/230
HANNAFIN, M.	COMPUTER-BASED INSTRUCTION	86/336
HANNAFIN, M.	MATHEMATICS	85/252
HANNAFIN, M.	COMPUTER-ASSISTED INSTRUCTION	85/252
HANNAFIN, M.J	INTERACTIVE VIDEO	87/297
HANNAFIN, M.J.	ORIENTING ACTIVITIES	87/585
HANNAFIN, M.J.	MEDIA UTILIZATION	86/153
HANNAFIN, M.J.	PROBLEM SOLVING SKILLS	87/599
HANNAFIN, M.J.	PRACTICE	87/297
HANNAFIN, M.J.	COMPUTER-BASED REINFORCEMENT	85/101
HANNAFIN, M.J.	ATTITUDE	86/153
HANNAFIN, M.J.	PRACTICE	87/599
HANNAFIN, M.J.	ACHIEVEMENT	85/101
HANNAFIN, M.J.	PRACTICE	87/585
HANNAFIN, M.J.	COMPUTER-BASED INSTRUCTION	87/277
HANNAFIN, M.J.	ORIENTING ACTIVITIES	87/599
HANNAFIN, M.J.	PRACTICE	87/277
HANNAFIN, M.J.	INTERACTIVE VIDEO	87/585
HANNAFIN, M.J.	LOCUS OF CONTROL	87/297
HANSON, C.	CONSCIOUSNESS	87/259
HANSON, C.	PSYCHOTECHNOLOGY	87/259
HART, R. A.	MEDIA ATTRIBUTES	86/358
HART, R.A.	CONCEPT LEARNING	85/332
HART, R.A.	SYNTACTIC PLACEMENT	85/332
HART. R.A.	VISUALIZATION	86/358
HARVEY, F.A.	INTERACTIVE VIDEO	87/152
HARVEY, F.A.	VIDEODISC	87/152
HO, M.L.	TEACHING INSTITUTIONS	85/372
HO, M.L.	CURRICULUM DIRECTORS	85/372
HO, M.L.	COLLECTION SCALES	86/390
HO, M.L.	MAPPING	86/390
HORTIN, J.A.	PUZZLE SOLVING	85/386
HORTIN, J.A.	TEACHER/PRINCIPAL ATTITUDES	86/410
HORTIN, J.A.	IMAGERY	85/386
HORTIN, J.A.	MEDIA LIBRARIES	86/410
HOUSE, J.D.	CURRICULUM CHANGES	86/421
HOUSE, J.D.	GRADUATE EDUCATION	86/421
HURT, J.A.	ILLUSTRATIONS	85/392
HURT, J.A.	PROSE	85/392
HUYVAERT, S.H.	QUEUEING THEORY	87/313
JACOBS, J.W.	TRANSFER OF LEARNING	87/337
JACOBS, J.W.	ATTENTION REDUCTION TRAINING	87/337
JONASSEN D.H.	PERCEPTUAL/COGNITIVE TASK	86/451

JONASSEN, D. H.	SEARCH TASK	86/469
JONASSEN, D.H.	COMPUTERPHOBIA	86/461
JONASSEN, D.H.	COMPUTER DISPLAY	86/451
JONASSEN, D.H.	STATE ANXIETY	86/461
JONASSEN, D.H.	LIST VS. FLOW CHART	86/469
JONES, P.E.	RESEARCH	86/478
JONES, P.E.	INSTRUCTIONAL TELEVISION	86/478
JOSEPH, J.H.	VISUAL IMAGERY REHEARSAL	87/361
JOSEPH, J.H.	FIELD DEPENDENCE/INDEPENDENCE	87/361
KERR, S.T.	MENTAL MODELS	87/373
KERR, S.T.	DATABASE STRUCTURE	87/373
KING, D.S.	VIDEO	87/625
KING, D.S.	MEDIA SELECTION	87/625
KING, J.W.	CASE STUDY METHODOLOGY	85/418
KING, J.W.	COMMUNICATION PROGRAMS	85/418
KLEIN, J.D.	COMPUTER-ASSISTED INSTRUCTION	87/401
KLEIN, J.D.	PROGRESSIVE STATE DRILL	87/401
KLOOK, T	PERSUASION	85/750
KLOOK, T	LEARNING STYLES	85/750
KNUPFER, N.N.	TEACHER ATTITUDES	87/419
KNUPFER, N.N.	COMPUTER ACCESS EQUITY	87/419
KOETTING, J.R.	VIDEO	85/437
KOETTING, J.R.	TEACHING ANALYSIS	85/437
KULIK, C.C.	COMPUTER-BASED INSTRUCTION	87/1
KULIK, J.E.	COMPUTER-BASED INSTRUCTION	87/1
LAMBERSKI, R.J.	NONCOMMERCIAL FM RADIO	86/505
LAMBERSKI, R.J.	TELEVISION	86/185
LAMBERSKI, R.J.	TELEVISION	86/195
LAMBERSKI, R.J.	AFFILIATED CABLE TELEVISION	86/185
LAMBERSKI, R.J.	RADIO	86/505
LAMBERSKI, R.J.	AFFILIATED CABLE TELEVISION	86/195
LAMBERSKI. R.J.	RADIO	86/490
LAMBERSKI. R.J.	NONCOMMERCIAL FM RADIO	86/490
LEIDMAN, M.B.	RADIO	86/505
LEIDMAN, M.B.	NONCOMMERCIAL FM RADIO	86/505
LEIDMAN, M.B.	RADIO	86/490
LEIDMAN,M.B.	NONCOMMERCIAL FM RADIO	86/490
LI, R.	SCHEMA ACTIVATION	87/459
LI, R.	TELEVISION	87/235
LI, R.	RECALL	87/235
LI, R.	PRE-INSTRUCTIONAL STRATEGIES	87/459
LITCHFIELD, B.C.	RECALL	87/235
LITCHFIELD, B.C.	TELEVISION	87/235
LOERTSCHER, D.	MAPPING	86/390
LOERTSHCER. D.	COLLECTION SCALES	86/390
LYNCH, B.E.	FILMIC CODING	86/521
LYNCH, B.E.	SPATIAL RELATIONSHIPS	86/521
LYNESS, A.L.	INTERACTIVE VIDEO	85/462
MATHISON, C.	ANALOGICAL REASONING	87/471
MATHISON, C.	DIAGRAMS	87/471
MATTHIAS, M.	COMPUTERS	85/703
METALLINOS, N.	COMPUTERIZED IMAGES	87/481
METALLINOS, N.	TELEVISION	87/481

MOLENDA, M.	INSTRUCTIONAL DEVELOPMENT	87/513
MOLENDA, M.	RESEARCH	87/513
MOLINA, R.R.	RESEARCH	85/479
MOLINA, R.R.	SPATIAL VISUALIZATION	85/479
MOORE, D.M.	IMAGERY	85/485
MOORE, D.M.	FIELD DEPENDENCE/INDEPENDENCE	85/485
MORIN, A.	THEORY	85/499
MORIN, A.	INSTRUCTIONAL TECHNOLOGY	85/499
MORRISON, G.R.	COMPUTER-BASED INSTRUCTION	87/639
MORRISON, G.R.	COMPUTER-MANAGED INSTRUCTION	86/530
MORRISON, G.R.	REGRESSION MODEL	86/530
MOSELY, M.L.	COMPUTERS	86/620
MOSELY. M.L.	MOTIVATION	86/620
MUFFOLETTO, R.	TEACHER SOCIALIZATION	85/318
MUFFOLETTO, R.	COMPUTERS	85/318
NEWHOUSE, B.S.	COMPUTER-ASSISTED INSTRUCTION	87/535
NEWHOUSE, B.S.	ASSOCIATIVE LEARNING	87/535
NICHOLS, R.	NOTETAKING	85/848
NICHOLS, R.	LEARNING STRATEGIES	85/848
NICHOLS, R.G.	EDUCATIONAL TECHNOLOGY	87/553
NISHIKAWA, S.S.	FEEDBACK	85/530
O'DELL, J.K.	COMPUTER-BASED INSTRUCTION	87/639
OLSON, J.S.	TECHNICAL PRESENTATIONS	85/558
OLSON, J.S.	SPEECH	85/558
PEARSON, M.	LIST VS. FLOW CHART	86/469
PEARSON, M.	SEARCH TASK	86/469
PERKINS, D.J.	FILM	87/575
PERKINS, D.J.	RESEARCH	87/575
PHILLIPS, T.L.	ORIENTING ACTIVITIES	87/585
PHILLIPS, T.L.	PRACTICE	87/585
PHILLIPS, T.L.	INTERACTIVE VIDEO	87/585
PHILLIPS, T.L.	COMPUTER-BASED INSTRUCTION	86/336
RAGAN, T.J.	INSTRUCTIONAL DESIGN	86/542
RAGAN. T.J.	CAI STRATEGIES	86/542
RANDALL, J.P.	EVALUATION	86/552
RANDALL, J.P.	MEDIA SERVICES	86/552
REHN, R.A.	DOGMATISM	85/557
REHN, R.A.	INSTRUCTIONAL METHODS	85/557
RIEBER, L. P.	PROBLEM SOLVING	86/562
RIEBER, L.P.	ORIENTING ACTIVITIES	87/599
RIEBER, L.P.	LOGO LANGUAGE	86/562
RIEBER, L.P.	EFFICACY OF LOGO	86/562
RIEBER, L.P.	PROBLEM SOLVING SKILLS	87/599
RIEBER, L.P.	PRACTICE	87/599
RIEBER, L.P.	COMPUTER-BASED INSTRUCTION	86/336
RIGGS, D.E.	TIME MANAGEMENT	86/252
RIGGS, D.E.	LIBRARY MANAGEMENT	86/252
ROBINSON, R.S.	INTERACTIVE CABLE TELEVISION	86/598
ROBINSON, R.S.	INTERACTIVE TELEVISION	85/623
RODRIGUEZ, S.	SIGNALING	87/613
RODRIGUEZ, S.	SCHEMA THEORY	87/613
RODRIGUEZ, S.	TEXT DESIGN	87/613
RODRIGUEZ, S.R.	VIDEO	87/625

RODRIGUEZ, S.R.	MEDIA SELECTION	87/625
ROSS, S.M.	COMPUTER-MANAGED INSTRUCTION	86/530
ROSS, S.M.	REGRESSION MODEL	86/530
ROSS, S.M.	COMPUTER-BASED INSTRUCTION	87/639
ROSSETT, A.	INSTRUCTIONAL DESIGN	86/612
SABA, F.	RESEARCH	87/661
SABA, F.	DISTANCE EDUCATION	87/661
SALCEDO, A.M.	INSTRUCTIONAL TELEVISION	85/650
SALISBURY, D.F.	TRANSFER OF LEARNING	87/337
SALISBURY, D.F.	PROGRESSIVE STATE DRILL	87/401
SALISBURY, D.F.	ATTENTION REDUCTION TRAINING	87/337
SALISBURY, D.F.	DRILL AND PRACTICE	85/663
SALISBURY, D.F.	COMPUTERS	85/663
SALISBURY, D.F.	COMPUTER-ASSISTED INSTRUCTION	87/401
SEIDMAN, S.A.	MEDIA UTILIZATION	85/678
SEIDMAN, S.A.	TEACHER BURNOUT	85/678
SEIDNER, C.J.	COMPUTER-BASED INSTRUCTION	85/889
SEIDNER, C.J.	TASK PERFORMANCE	85/889
SEYMOUR, S.L.	COMPUTERS	86/620
SEYMOUR, S.L.	MOTIVATION	86/620
SHAW, S.	COMPUTERS	85/703
SHROCK, S.A.	COMPUTERS	85/703
SILVERSTEIN, M.A.	SOCIAL INTERACTION	85/717
SILVERSTEIN, M.A.	VIDEODISC SYSTEM	85/717
SIMONSON, M. R.	SUBLIMINAL MESSAGES	86/763
SIMONSON, M.R.	PERSUASION	85/750
SIMONSON, M.R.	PERSUASION	86/763
SIMONSON, M.R.	LEARNING STYLES	85/750
SIMONSON, M.R.	RESEARCH	87/1
SMITH, P.	COMPUTER-BASED INSTRUCTION	86/656
SMITH, P.	SIMULATION	86/656
SMITH, P.L.	TEXT DESIGN	85/783
SMITH, P.L.	CUEING	86/635
SMITH, P.L.	PROCESSING	86/635
STACY, N.O.	COMPUTERS	86/620
STEVENS, J.T.	RECALL	87/49
STEVENS, J.T.	PICTURES	87/49
STEVENSON, R.B.	COMPUTER LITERACY	85/797
STEVENSON, R.B.	EMPOWERED LEARNING	85/797
STONE, R.	LEARNING STYLES	85/750
STONE, R.	PERSUASION	85/750
STORM, S.R.	CHILDREN	85/813
STORM, S.R.	TELEVISION	85/813
STORY, N.O.	MOTIVATION	86/620
SULLIVAN, H.J.	COMPUTERS	86/620
SULLIVAN, H.J.	MOTIVATION	86/620
SUTHERLAND, S.	COGNITIVE PROCESSING	87/681
SUTHERLAND, S.	VISUAL FEATURES OF MAPS	87/681
SUZUKI, K.	DOMAIN INTEGRATION DESIGN	87/67
SUZUKI, K.	SCHEMA THEORY	87/697
TAYLOR, W.	LEARNING STRATEGIES	85/848
TAYLOR, W.	LEARNING STRATEGIES	87/709
TAYLOR, W.	PACING	86/65

TAYLOR, W.	ENCODING	85/87
TAYLOR, W.	NOTETAKING	85/848
TAYLOR, W.	INSTRUCTIONAL STRATEGY	86/65
TAYLOR, W.	COMPUTER-BASED INSTRUCTION	87/709
TAYLOR, W.	INDIVIDUAL DIFFERENCES	85/146
TAYLOR, W.	COMPUTER-BASED INSTRUCTION	85/146
TAYLOR, W.	INSTRUCTIONAL DESIGN	85/87
TENNYSON, R.D.	RESEARCH	87/1
TENNYSON, R.D.	COMPUTER-BASED INSTRUCTION	87/119
TENNYSON, R.D.	MAIS	87/119
THOMPSON, M.E.	FIELD DEPENDENCE/INDEPENDENCE	87/733
THOMPSON, M.E.	TEXT LEARNING	87/733
TIENE, D.	INSTRUCTIONAL TELEVISOIN	86/721
TIENE, D.	TELEVISION	86/745
TIENE, D.	PUBLIC TELEVISION	86/721
TILLMAN, M.H.	ELECTRONIC MAIL	86/220
TORARDI, M.M.	COMPUTER LITERACY ASSESSMENT	85/860
TOUGER, H.E.	TASK PERFORMANCE	85/889
TOUGER, H.E.	COMPUTER-BASED INSTRUCTION	85/889
TREIMER, M.	PERSUASION	86/763
TREIMER, M.	SUBLIMINAL MESSAGES	86/763
TRIPP, S.D.	INTERACTIVE VIDEO	87/585
TRIPP, S.D.	ORIENTING ACTIVITIES	87/585
TRIPP, S.D.	PRACTICE	87/585
TSAI, C.	ARITHMETIC WORD PROBLEMS	87/745
TSAI, C.	SCHEMA THEORY	87/745
TWITCHELL, D.	DISTANCE EDUCATION	87/661
TWITCHELL, D.	RESEARCH	87/661
VENSEL, C.	COMPUTERS	85/703
WAGER, W.	TEXT RESEARCH	87/757
WAGER, W.	COMPUTER SCREEN DESIGN	87/757
WATSON, J.F.	WRITING SKILLS	86/166
WATSON, J.F.	WORD PROCESSING	86/166
WEDMAN, J. F.	COMPUTER INSERVICE	86/782
WEDMAN. J.F.	INSERVICE DESIGN	86/782
WELLIVER, P. W.	GRADUATE STUDENTS	86/797
WEST, P.C.	INTERACTIVE CABLE TELEVISION	86/598
WILLIAMSON, N.G.	MEDIA SELECTION	87/625
WILLIAMSON, N.G.	VIDEO	87/625
WILSON, B.G.	COMPUTER-ASSISTED INSTRUCTION	87/767
WILSON, B.G.	COMPUTER-BASED INSTRUCTION	85/901
WILSON, B.G.	INSTRUCTIONAL DESIGN	87/767
WILSON, B.G.	SYNTHESIZING STRATEGIES	85/901
WINN, W.	COMPUTER-ASSISTED INSTRUCTION	87/783
WINN, W.	GRAPHICS	87/783
WINN, W.	MEDIA	87/1
WINN, W.	VISUAL FEATURES OF MAPS	87/681
WINN, W.	ICAI SYSTEMS	87/783
WINN, W.	RESEARCH TRENDS	86/801
WINN, W.	COGNITIVE PROCESSING	87/681
YEAMAN, A.R.	PERSON-ENVIRONMENT FIT	86/833
YEAMAN, A.R.J.	ELECTRONIC BOOKS	85/921
YEAMAN, A.R.J.	WINDOW EFFECT	87/805
YEAMAN, A.R.J.	RESEARCH	85/921
YEAMAN, A.R.J.	TEXT DISPLAY	87/805

1985-1987 CUMULATIVE SUBJECT INDEX

DESCRIPTOR	AUTHOR'S NAME	YR/PG
ACHIEVEMENT	HANNAFIN, M.J.	85/101
ACQUISITION SKILLS	ALLEN, B.S.	85/29
ADVANCE ORGANIZER	HANCLOSKY, W.V.	86/313
AFFILIATED CABLE TELEVISION	DUDT, K.P.	86/195
AFFILIATED CABLE TELEVISION	LAMBERSKI, R.J.	86/185
AFFILIATED CABLE TELEVISION	LAMBERSKI, R.J.	86/195
AFFILIATED CABLE TELEVISION	DUDT, K.P.	86/185
ALGEBRA	ALBRIGHT, M.J.	85/1
ANALOGICAL REASONING	MATHISON, C.	87/471
ANALOGICAL REASONING	ALLEN, B.S.	87/471
ANALYTIC ABILITY	FRENCH, M.	85/193
APTITUDE-TREATMENT INTERACTION	DRISCOLL, M.P.	87/171
ARITHMETIC WORD PROBLEMS	TSAI, C.	87/745
ARITHMETIC WORD PROBLEMS	DERRY, S.J.	87/745
ASSOCIATIVE LEARNING	NEWHOUSE, B.S.	87/535
ATTENTION REDUCTION TRAINING	DEMPSEY, J.V.	87/337
ATTENTION REDUCTION TRAINING	JACOBS, J.W.	87/337
ATTENTION REDUCTION TRAINING	SALISBURY, D.F.	87/337
ATTITUDE	HANNAFIN, M.J.	86/153
ATTITUDE	DALTON, D.W.	86/153
ATTITUDE	DALTON, D. W.	86/119
ATTITUDES	CARL, R.R.	86/85
ATTITUDES	GREATHOUSE, S.	86/85
ATTITUDES	CARL, D.L.	86/85
CAI STRATEGIES	RAGAN. T.J.	86/542
CASE STUDY METHODOLOGY	KING, J.W.	85/418
CHILDREN	STORM, S.R.	85/813
COGNITION	FOSNOT, C.T.	85/164
COGNITION	FORMAN, G.E.	85/164
COGNITIVE MONITORING	GARHART,C.	86/230
COGNITIVE MONITORING	HANNAFIN, M.	86/230
COGNITIVE PROCESSING	WINN, W.	87/681
COGNITIVE PROCESSING	SUTHERLAND, S.	87/681
COLLECTION SCALES	HO, M.L.	86/390
COLLECTION SCALES	LOERTSHCER. D.	86/390
COMMUNICATION PROGRAMS	KING, J.W.	85/418
COMPARISON STRATEGIES	ALLEN, B.S.	85/29
COMPUTER ACCESS EQUITY	KNUPFER, N.N.	87/419
COMPUTER DISPLAY	JONASSEN, D.H.	86/451
COMPUTER GRAPHICS	CAMBRE, M.A.	86/36
COMPUTER GRAPHICS	BELLAND, J.C.	86/36
COMPUTER GRAPHICS	BAKER, P.R.	86/36
COMPUTER INSERVICE	WEDMAN, J. F.	86/782
COMPUTER LITERACY	STEVENSON, R.B.	85/797
COMPUTER LITERACY ASSESSMENT	TORARDI, M.M.	85/860
COMPUTER SCREEN DESIGN	WAGER, W.	87/757
COMPUTER-ASSISTED INSTRUCTION	HANNAFIN, M.	85/252
COMPUTER-ASSISTED INSTRUCTION	WILSON, B.G.	87/767
COMPUTER-ASSISTED INSTRUCTION	SALISBURY, D.F.	87/401
COMPUTER-ASSISTED INSTRUCTION	CHU, H.J.	87/133
COMPUTER-ASSISTED INSTRUCTION	KLEIN, J.D.	87/401
COMPUTER-ASSISTED INSTRUCTION	GOETZFRIED, L.	85/252
COMPUTER-ASSISTED INSTRUCTION	WINN, W.	87/783
COMPUTER-ASSISTED INSTRUCTION	NEWHOUSE, B.S.	87/535
COMPUTER-BASED INSTRUCTION	GARHART, C.	86/230

COMPUTER-BASED INSTRUCTION	BELLAND, J.	87/709
COMPUTER-BASED INSTRUCTION	KULIK, C.C.	87/1
COMPUTER-BASED INSTRUCTION	TAYLOR, W.	85/146
COMPUTER-BASED INSTRUCTION	HANNAFIN, M.J.	87/277
COMPUTER-BASED INSTRUCTION	CANELOS, J.	87/709
COMPUTER-BASED INSTRUCTION	KULIK, J.E.	87/1
COMPUTER-BASED INSTRUCTION	BAKER, P.	87/709
COMPUTER-BASED INSTRUCTION	WILSON, B.G.	85/901
COMPUTER-BASED INSTRUCTION	TOUGER, H.E.	85/889
COMPUTER-BASED INSTRUCTION	ROSS, S.M.	87/639
COMPUTER-BASED INSTRUCTION	HANNAFIN, M.	86/336
COMPUTER-BASED INSTRUCTION	GARHART, C.	86/336
COMPUTER-BASED INSTRUCTION	TAYLOR, W.	87/709
COMPUTER-BASED INSTRUCTION	HANNAFIN, M.	86/220
COMPUTER-BASED INSTRUCTION	DWYER, F.	87/709
COMPUTER-BASED INSTRUCTION	MORRISON, G.R.	87/639
COMPUTER-BASED INSTRUCTION	PHILLIPS, T.L.	86/336
COMPUTER-BASED INSTRUCTION	SMITH, P.	86/656
COMPUTER-BASED INSTRUCTION	SEIDNER, C.J.	85/889
COMPUTER-BASED INSTRUCTION	TENNYSON, R.D.	87/119
COMPUTER-BASED INSTRUCTION	BELLAND, J.	85/146
COMPUTER-BASED INSTRUCTION	O'DELL, J.K.	87/629
COMPUTER-BASED INSTRUCTION	DWYER, F.	85/146
COMPUTER-BASED INSTRUCTION	RIEBER, L.P.	86/336
COMPUTER-BASED INSTRUCTION	ANAND, P.	87/629
COMPUTER-BASED INSTRUCTION	CHRISTENSEN, D.L.	87/119
COMPUTER-BASED INSTRUCTION	BAKER, P.	85/146
COMPUTER-BASED INSTRUCTION	CANELOS, J.	85/146
COMPUTER-BASED INSTRUCTION	GARHART, C.	86/336
COMPUTER-BASED REINFORCEMENT	HANNAFIN, M.J.	85/101
COMPUTER-BASED REINFORCEMENT	DALTON, D.W.	85/101
COMPUTER-GENERATED TEXT	GRABINGER, R. S.	86/271
COMPUTER-MANAGED INSTRUCTION	MORRISON, G.R.	86/530
COMPUTER-MANAGED INSTRUCTION	ROSS, S.M.	86/530
COMPUTERIZED IMAGES	CHARTRAND, S.	87/481
COMPUTERIZED IMAGES	METALLINOS, N.	87/481
COMPUTERPHOBIA	JONASSEN, D.H.	86/461
COMPUTERS	STACY, N.O.	86/620
COMPUTERS	CARL, R.R.	86/85
COMPUTERS	SALISBURY, D.F.	85/663
COMPUTERS	MOSELY, M.L.	86/620
COMPUTERS	MUFFOLETTO, R.	85/318
COMPUTERS	VENSEL, C.	85/703
COMPUTERS	MATTHIAS, M.	85/703
COMPUTERS	SHROCK, S.A.	85/703
COMPUTERS	SEYMOUR, S.L.	86/620
COMPUTERS	SHAW, S.	85/703
COMPUTERS	SULLIVAN, H.J.	86/620
COMPUTERS	GRIBBLE, M.	85/318
COMPUTERS	GREATHOUSE, S.	86/85
COMPUTERS	GAMSKY, D.	85/318
COMPUTERS	ANASTASOFF, J.	85/703
COMPUTERS	CARL, D.L.	86/85

CONCEPT LEARNING	HART, R.A.	85/332
CONSCIOUSNESS	HANSON, C.	87/259
CONSCIOUSNESS	GUEULETTE, D.G.	87/259
COURSEWARE	ALESANDRINI, K.	85/18
CUEING	SMITH, P.L.	86/635
CURRICULUM CHANGES	BRATTON, B.	86/421
CURRICULUM CHANGES	HOUSE, J.D.	86/421
CURRICULUM CHANGES	GJERDE, C.L.	86/421
CURRICULUM DIRECTORS	HO, M.L.	85/372
DATABASE STRUCTURE	KERR, S.T.	87/373
DIAGRAMS	ALLEN, B.S.	87/471
DIAGRAMS	MATHISON, C.	87/471
DISTANCE EDUCATION	TWITCHELL, D.	87/661
DISTANCE EDUCATION	SABA, F.	87/661
DOGMATISM	REHN, R.A.	85/557
DOMAIN INTEGRATION DESIGN	SUZUKI, K.	87/67
DRILL AND PRACTICE	SALISBURY, D.F.	85/663
EDUCATIONAL TECHNOLOGY	NICHOLS, R.G.	87/553
EFFICACY OF LOGO	RIEBER, L.P.	86/562
EFFICACY OF LOGO	DALTON, D.W.	86/119
ELECTRONIC BOOKS	YEAMAN, A.R.J.	85/921
ELECTRONIC MAIL	TILLMAN, M.H.	86/220
ELECTRONIC MAIL	GARDNER, C.H.	86/220
EMPOWERED LEARNING	STEVENSON, R.B.	85/797
ENCODING	BELLAND, J.	85/87
ENCODING	TAYLOR, W.	85/87
ENCODING	DWYER, F.	85/87
ENCODING	CANELOS, J.	85/87
EVALUATION	BENDER, E.	87/99
EVALUATION	RANDALL, J.P.	86/552
FEEDBACK	NISHIKAWA, S.S.	85/530
FIELD DEPENDENCE/INDEPENDENCE	MOORE, D.M.	85/485
FIELD DEPENDENCE/INDEPENDENCE	JOSEPH, J.H.	87/361
FIELD DEPENDENCE/INDEPENDENCE	THOMPSON, M.E.	87/733
FILM	ERDMAN, B.	87/221
FILM	BOWIE, M.M.	86/49
FILM	PERKINS, D.J.	87/575
FILM - HISTORICAL ANALYSIS	ELLSWORTH, E.	87/205
FILM THEORY	DEGRAFF, J.	85/125
FILMIC CODING	LYNCH, B.E.	86/521
GRADUATE EDUCATION	HALES. R.H.	86/302
GRADUATE EDUCATION	HOUSE, J.D.	86/421
GRADUATE EDUCATION	BRATTON, B.	86/421
GRADUATE EDUCATION	FELT, S.B.	86/302
GRADUATE EDUCATION	GJERDE, C.L.	86/421
GRADUATE STUDENTS	HELLIVER, P. W.	86/797
GRAPHICS	WINN, W.	87/783
GRAPHICS	ALESANDRINI, K.	85/18
ICAI SYSTEMS	WINN, W.	87/783
ILLUSTRATIONS	HURT, J.A.	85/392
ILLUSTRATIONS	ANGLIN, G.J.	85/57
IMAGERY	HORTIN, J.A.	85/386
IMAGERY	MOORE, D.M.	85/485

INCENTIVE	ALBRIGHT, M.J.	85/1
INDIVIDUAL DIFFERENCES	TAYLOR, W.	85/146
INDIVIDUAL DIFFERENCES	CANELOS, J.	85/146
INDIVIDUAL DIFFERENCES	BELLAND, J.	85/146
INDIVIDUAL DIFFERENCES	BAKER, P.	85/146
INDIVIDUAL DIFFERENCES	DWYER, F.	85/146
INSERVICE DESIGN	WEDMAN. J.F.	86/782
INSTRUCTION	FRENCH, M.	85/220
INSTRUCTIONAL DESIGN	BELLAND, J.	85/87
INSTRUCTIONAL DESIGN	WILSON, B.G.	87/767
INSTRUCTIONAL DESIGN	TAYLOR, W.	85/87
INSTRUCTIONAL DESIGN	RAGAN, T.J.	86/542
INSTRUCTIONAL DESIGN	ROSSETT, A.	86/612
INSTRUCTIONAL DESIGN	CANELOS, J.	85/87
INSTRUCTIONAL DESIGN	ELLSWORTH, E.	87/205
INSTRUCTIONAL DESIGN	DWYER, F.	85/87
INSTRUCTIONAL DEVELOPMENT	MOLENDA, M.	87/513
INSTRUCTIONAL METHODS	REHN, R.A.	85/557
INSTRUCTIONAL STRATEGIES	FRENCH, M.	85/193
INSTRUCTIONAL STRATEGY	BAKER, P.	86/65
INSTRUCTIONAL STRATEGY	BELLAND, J.	86/177
INSTRUCTIONAL STRATEGY	CANELOS, J.	86/65
INSTRUCTIONAL STRATEGY	DWYER, F.	86/65
INSTRUCTIONAL STRATEGY	TAYLOR, W.	86/65
INSTRUCTIONAL TECHNOLOGY	GAGNON, R.	85/232
INSTRUCTIONAL TECHNOLOGY	MORIN, A.	85/499
INSTRUCTIONAL TELEVISION	JONES, P.E.	86/478
INSTRUCTIONAL TELEVISION	SALCEDO, A.M.	85/650
INSTRUCTIONAL TELEVISOIN	TIENE, D.	86/721
INTERACTIVE CABLE TELEVISION	WEST, P.C.	86/598
INTERACTIVE CABLE TELEVISION	ROBINSON, R.S.	86/598
INTERACTIVE TELEVISION	ROBINSON, R.S.	85/623
INTERACTIVE VIDEO	COLAMAIO, M.E.	87/297
INTERACTIVE VIDEO	TRIPP, S.D.	87/585
INTERACTIVE VIDEO	ABRAMS, A.	86/1
INTERACTIVE VIDEO	BROVEY, A.J.	87/152
INTERACTIVE VIDEO	PHILLIPS, T.L.	87/585
INTERACTIVE VIDEO	HANNAFIN, M.J	87/297
INTERACTIVE VIDEO	CUSHALL, M.B.	87/152
INTERACTIVE VIDEO	HARVEY, F.A.	87/152
INTERACTIVE VIDEO	HANNAFIN, M.J.	87/585
INTERACTIVE VIDEO	LYNESS, A.L.	85/462
INTROVERTED APPROACH	AUST, R.J.	87/63
LEARNING STRATEGIES	TAYLOR, W.	87/709
LEARNING STRATEGIES	DWYER, F.	87/709
LEARNING STRATEGIES	CANELOS, J.	85/848
LEARNING STRATEGIES	TAYLOR, W.	85/848
LEARNING STRATEGIES	CANELOS, J.	85/848
LEARNING STRATEGIES	BELLAND, J.	87/709
LEARNING STRATEGIES	NICHOLS, R.	85/848
LEARNING STRATEGIES	BAKER, P.	87/709
LEARNING STRATEGIES	CANELOS, J.	87/709
LEARNING STRATEGIES	DWYER, F.	85/848

LEARNING STYLES	COOK, S.	85/750
LEARNING STYLES	STONE, R.	85/750
LEARNING STYLES	BOWIE, M.M.	86/49
LEARNING STYLES	KLOOK, T	85/750
LEARNING STYLES	BERRY, T.	85/750
LEARNING STYLES	AEGERTER, R.	85/750
LEARNING STYLES	SIMONSON, M.R.	85/750
LIBRARY MANAGEMENT	GOTHBERG, H.M.	86/252
LIBRARY MANAGEMENT	ALEAMONI, L.M.	86/252
LIBRARY MANAGEMENT	RIGGS, D.E.	86/252
LIST VS. FLOW CHART	PEARSON, M.	86/469
LIST VS. FLOW CHART	JONASSEN, D.H.	86/469
LITERACY	GRIFFIN, S.M.	87/247
LOCUS OF CONTROL	HANNAFIN, M.J.	87/297
LOCUS OF CONTROL	COLAMAIO, M.E.	87/297
LOGO LANGUAGE	DALTON, D.W.	86/562
LOGO LANGUAGE	RIEBER, L.P.	86/562
MAIS	TENNYSON, R.D.	87/119
MAIS	CHRISTENSEN, D.L.	87/119
MANAGEMENT	HALES, R.L.	86/302
MANAGEMENT	FELT, S.B.	86/302
MAPPING	HO, M.L.	86/390
MAPPING	LOERTSCHER, D.	86/390
MATHEMATICS	HANNAFIN, M.	85/252
MATHEMATICS	GOETZFRIED, L.	85/252
MEDIA	WINN, W.	87/1
MEDIA ANALYSIS	BECKER, A.D.	87/83
MEDIA ATTRIBUTES	HART, R. A.	86/358
MEDIA LIBRARIES	HORTIN, J.A.	86/410
MEDIA SELECTION	KING, D.S.	87/625
MEDIA SELECTION	WILLIAMSON, N.G.	87/625
MEDIA SELECTION	RODRIGUEZ, S.R.	87/625
MEDIA SELECTION	EVANS, L.J.	86/210
MEDIA SERVICES	RANDALL, J.P.	86/552
MEDIA UTILIZATION	HANNAFIN, M.J.	86/153
MEDIA UTILIZATION	CHUTE, A.G.	86/106
MEDIA UTILIZATION	SEIDMAN, S.A.	85/678
MEDIA UTILIZATION	DALTON, D.W.	86/153
MENTAL MODELS	KERR, S.T.	87/373
MICROCOMPUTER SOFTWARE	BENDER, E.	87/99
MOTIVATION	SULLIVAN, H.J.	86/620
MOTIVATION	SEYMOUR, S.L.	86/620
MOTIVATION	STORY, N.O.	86/620
MOTIVATION	MOSELY. M.L.	86/620
NARROW-CAST TELEVISION	DALTON, D.W.	87/161
NONCOMMERCIAL FM RADIO	LAMBERSKI, R.J.	86/505
NONCOMMERCIAL FM RADIO	LEIDMAN,M.B.	86/490
NONCOMMERCIAL FM RADIO	LEIDMAN, M.B.	86/505
NONCOMMERCIAL FM RADIO	LAMBERSKI. R.J.	86/490
NOTETAKING	NICHOLS, R.	85/848
NOTETAKING	TAYLOR, W.	85/848
NOTETAKING	CANELOS, J.	85/848
NOTETAKING	DWYER, F.	85/848

ORIENTING ACTIVITIES	RIEBER, L.P.	87/599
ORIENTING ACTIVITIES	TRIPP, S.D.	87/585
ORIENTING ACTIVITIES	HANNAFIN, M.J.	87/599
ORIENTING ACTIVITIES	PHILLIPS, T.L.	87/585
ORIENTING ACTIVITIES	HANNAFIN, M.J.	87/585
PACING	TAYLOR, W.	86/65
PACING	BELLAND, J.	86/65
PACING	DWYER, F.	86/65
PACING	CANELOS, J.	86/65
PACING	BAKER, P.	86/65
PERCEPTUAL MODE	GRIFFIN, S.M.	87/247
PERCEPTUAL PROCESSES		
PERCEPTUAL PROCESSES	AUST, R.J.	87/63
PERCEPTUAL/COGNITIVE TASK	JONASSEN D.H.	86/451
PERSON-ENVIRONMENT FIT	YEAMAN, A.R.	86/833
PERSUASION	BERRY, T.	85/750
PERSUASION	STONE, R.	85/750
PERSUASION	SIMONSON, M.R.	85/750
PERSUASION	AEGERTER, R.	85/750
PERSUASION	KLOOK, T	85/750
PERSUASION	SIMONSON, M.R.	86/763
PERSUASION	TREIMER, M.	86/763
PERSUASION	COOK, S.	85/750
PHOTOGRAPHY SKILLS	ABRAMS, A.	86/1
PICTURE EFFECTS	ANGLIN, G.J.	86/15
PICTURES	ANGLIN, G.J.	87/49
PICTURES	STEVENS, J.T.	87/49
PRACTICE	COLAMAIO, M.E.	87/297
PRACTICE	HANNAFIN, M.J.	87/585
PRACTICE	HANNAFIN, M.J.	87/277
PRACTICE	HANNAFIN, M.J.	87/297
PRACTICE	PHILLIPS, T.L.	87/585
PRACTICE	HANNAFIN, M.J.	87/599
PRACTICE	TRIPP, S.D.	87/585
PRACTICE	RIEBER, L.P.	87/599
PRACTICE STRATEGIES	DWYER, C.A.	87/183
PRE-INSTRUCTIONAL STRATEGIES	LI, R.	87/459
PROBLEM SOLVING	RIEBER, L. P.	86/562
PROBLEM SOLVING SKILLS	HANNAFIN, M.J.	87/599
PROBLEM SOLVING SKILLS	RIEBER, L.P.	87/599
PROCESSING	SMITH, P.L.	86/635
PROGRESSIVE STATE DRILL	KLEIN, J.D.	87/401
PROGRESSIVE STATE DRILL	SALISBURY, D.F.	87/401
PROSE	HURT, J.A.	85/392
PROSE	ANGLIN, G.J.	85/57
PSYCHOTECHNOLOGY	GUEULETTE, D.G.	87/259
PSYCHOTECHNOLOGY	HANSON, C.	87/259
PUBLIC TELEVISION	TIENE, D.	86/721
PUZZLE SOLVING	HORTIN, J.A.	85/386
QUEUEING THEORY	HUYVAERT, S.H.	87/313
RADIO	LEIDMAN, M.B.	86/490
RADIO	LAMBERSKI. R.J.	86/490
RADIO	LEIDMAN, M.B.	86/505

RADIO	LAMBERSKI, R.J.	86/505
READER THEORIES	BECKER, A.D.	87/83
READING	CHU, H.J.	87/133
RECALL	ANGLIN, G.J.	86/15
RECALL	STEVENS, J.T.	87/49
RECALL	ANGLIN, G.J.	87/49
RECALL	GREENE, E.C.	87/235
RECALL	LI, R.	87/235
RECALL	LITCHFIELD, B.C.	87/235
REGRESSION MODEL	MORRISON, G.R.	86/530
REGRESSION MODEL	ROSS, S.M.	86/530
REINFORCEMENT	DALTON, D.W.	85/101
RESEARCH	TENNYSON, R.D.	87/1
RESEARCH	CLARK, R.E.	87/1
RESEARCH	MOLINA, R.R.	85/479
RESEARCH	YEAMAN, A.R.J.	85/921
RESEARCH	FRENCH, M.	85/220
RESEARCH	TWITCHELL, D.	87/661
RESEARCH	SABA, F.	87/661
RESEARCH	SIMONSON, M.R.	87/1
RESEARCH	MOLENDA, M.	87/513
RESEARCH	BECKER, A.	85/72
RESEARCH	PERKINS, D.J.	87/575
RESEARCH	JONES, P.E.	86/478
RESEARCH TRENDS	WINN, W.	86/801
SCHEMA ACTIVATION	LI, R.	87/459
SCHEMA THEORY	DERRY, S.J.	87/745
SCHEMA THEORY	GAGNE, R.M.	87/229
SCHEMA THEORY	RODRIGUEZ, S.	87/613
SCHEMA THEORY	TSAI, C.	87/745
SCHEMA THEORY	SUZUKI, K.	87/697
SCREEN DESIGN	BELLAND, J.C.	86/36
SCREEN DESIGN	CAMBRE, M.A.	86/36
SCREEN DESIGN	BAKER, P.R.	86/36
SEARCH TASK	PEARSON, M.	86/469
SEARCH TASK	JONASSEN, D. H.	86/469
SIGNALING	RODRIGUEZ, S.	87/613
SIMULATION	SMITH, P.	86/656
SOCIAL INTERACTION	SILVERSTEIN, M.A.	85/717
SOCIAL ISSUES	ERDMAN, B.	87/221
SPATIAL RELATIONSHIPS	LYNCH, B.E.	86/521
SPATIAL VISUALIZATION	MOLINA, R.R.	85/479
SPEECH	OLSON, J.S.	85/558
STATE ANXIETY	JONASSEN, D.H.	86/461
SUBLIMINAL MESSAGES	TREIMER, M.	86/763
SUBLIMINAL MESSAGES	SIMONSON, M. R.	86/763
SYNTACTIC PLACEMENT	HART, R.A.	85/332
SYNTHESIZING STRATEGIES	WILSON, B.G.	85/901
TASK ANALYSIS	HANCLOSKY, W. V.	86/313
TASK PERFORMANCE	SEIDNER, C.J.	85/889
TASK PERFORMANCE	TOUGER, H.E.	85/889
TEACHER ATTITUDES	KNUPFER, N.N.	87/419
TEACHER BURNOUT	SEIDMAN, S.A.	85/678

TEACHER SOCIALIZATION	GRIBBLE, M.	85/318
TEACHER SOCIALIZATION	GAMSKY, D.	85/318
TEACHER SOCIALIZATION	MUFFOLETTO, R.	85/318
TEACHER/PRINCIPAL ATTITUDES	HORTIN, J.A.	86/410
TEACHING ANALYSIS	KOETTING, J.R.	85/437
TEACHING INSTITUTIONS	HO, M.L.	85/372
TECHNICAL PRESENTATIONS	OLSON, J.S.	85/558
TELETRAINING	CHUTE, A.G.	86/106
TELEVISION	LITCHFIELD, B.C.	87/235
TELEVISION	DUDT, K.P.	86/195
TELEVISION	LAMBERSKI, R.J.	86/185
TELEVISION	TIENE, D.	86/745
TELEVISION	LAMBERSKI, R.J.	86/195
TELEVISION	DEGRAFF, J.	85/125
TELEVISION	DUDT, K.P.	86/185
TELEVISION	GREENE, E.C.	87/235
TELEVISION	LI, R.	87/235
TELEVISION	METALLINOS, N.	87/481
TELEVISION	CHARTRAND, S.	87/481
TELEVISION	STORM, S.R.	85/813
TELEVISION	DALTON, D.W.	87/161
TEXT DESIGN	SMITH, P.L.	85/783
TEXT DESIGN	RODRIGUEZ, S.	87/613
TEXT DISPLAY	YEAMAN, A.R.J.	87/805
TEXT FORMAT	GRABINGER, R.S.	86/271
TEXT LAYOUT	GRABINGER, R.S.	85/280
TEXT LAYOUT	AMEDEO, D.	85/280
TEXT LEARNING	THOMPSON, M.E.	87/733
TEXT RESEARCH	WAGER, W.	87/757
THEORY	BECKER, A.	85/72
THEORY	MORIN, A.	85/499
TIME MANAGEMENT	GOTHBERG, H.M.	86/252
TIME MANAGEMENT	RIGGS, D.E.	86/252
TRANSFER OF LEARNING	JACOBS, J.W.	87/337
TRANSFER OF LEARNING	DEMPSEY, J.V.	87/337
TRANSFER OF LEARNING	SALISBURY, D.F.	87/337
VIDEO	KOETTING, J.R.	85/437
VIDEO	FOSNOT, C.T.	85/164
VIDEO	FORMAN, G.E.	85/164
VIDEO	RODRIGUEZ, S.R.	87/625
VIDEO	KING, D.S.	87/625
VIDEO	WILLIAMSON, N.G.	87/625
VIDEODISC	CUSHALL, M.B.	87/152
VIDEODISC	HARVEY, F.A.	87/152
VIDEODISC	BROVEY, A.J.	87/152
VIDEODISC SYSTEM	SILVERSTEIN, M.A.	85/717
VISUAL FEATURES OF MAPS	SUTHERLAND, S.	87/681
VISUAL FEATURES OF MAPS	WINN, W.	87/681
VISUAL IMAGERY REHEARSAL	JOSEPH, J.H.	87/361
VISUALIZATION	HART. R.A.	86/358
VISUALIZED INSTRUCTION	DWYER, C.A.	87/183
WINDOW EFFECT	YEAMAN, A.R.J.	87/805
WORD PROCESSING	DALTON, D.W.	86/166
WORD PROCESSING	WATSON, J.F.	86/166
WRITING SKILLS	DALTON, D.W.	86/166
WRITING SKILLS	WATSON, J.F.	86/166